ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 — TELEPHONE: TEMPLE BAR 3163

Vol. 180 No. 4681 — LONDON, FRIDAY, OCTOBER 14, 1955 — PRICE 2s.

UNIVERSITY OF MICHIGAN
OCT 31
ENGINEERING

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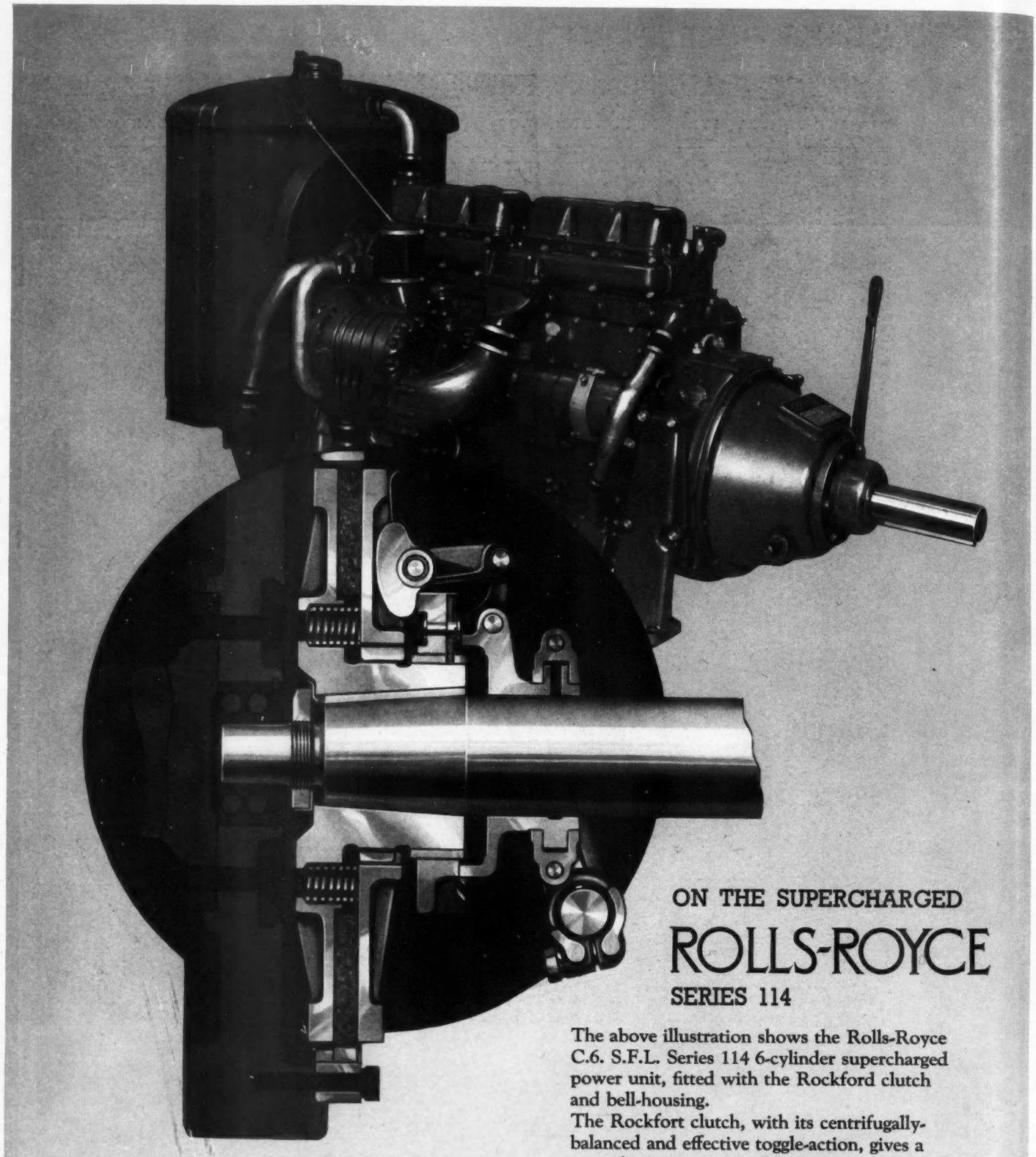

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ENGINEERING

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Published every Friday by Engineering Limited 35 & 36 *Bedford Street, Strand, London, W.C.2*
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

WAR IN PEACE

THE Prime Minister's plan for reducing the number of national service men is a welcome step in the right direction. The rough justice of national service, modified as it is by special exceptions, deprives the country of brawn and brain that it can ill afford to lose. Taken in conjunction with his other plan to widen the powers of the Minister of Defence, it is evidence of a new pattern in defensive effort. But there is still little evidence that the Government are creating a top-level organisation suited to the development and use of modern weapons. The Army Council, for example, is composed largely of former infantry and gunner officers who have no background of scientific training. With the possible exception of a former sapper officer, none of the men who direct Army policy has had the kind of experience which is vital to a technically equipped force. It is as though I.C.I. were run by a board of Nineteenth Century directors.

The Royal Commission on Awards to Inventors have taken ten years to weigh the claims of men who played a big part in winning the war. Ideas practical and impracticable were not lacking in the 1940's. But while these men were fighting their own private wars against official inertia, others in the field were fighting with out-classed weapons. There was a dreadful contrast between, on one hand, the long hours and earnest efforts of the production shops and, on the other, the frustration experienced by soldiers who could see what was needed but were powerless to stimulate any action back in the home country. In the language of modern control engineering, feedback of information was almost entirely lacking or was interrupted in transit.

If that shortcoming was serious 15 years ago it would be doubly so to-day. The armed forces are given equipment that is more highly developed, technically, than any civilian equipment; designs are constantly being improved, but the improvements appear to be made without the benefit of an efficient feedback system which completes the circle of design, use, development, design. In most spheres of engineering the designer commonly knows more about use than the user knows about design. That is inevitable with radio sets and motor-cars, but in the case of armaments the gulf between user and designer retards development. The services must know enough about design to be able to ask for weapons that are more advanced than anything they have. It is not sufficient for the dam-busting bomb always to be the brain-child of a lone scientist; the serving officer must originate at least as many ideas. And he can only do that if he has technical knowledge and imagination. Not all serving officers can aspire to this double qualification, but some should have it and be given the opportunity to use it.

In the Army the tradition of two world wars is that the technical officer's job is maintenance of equipment. What is now needed is an extension of this function to the stage where technical officers are on the General Staff, at all levels from the Army Council down, to make a positive contribution to armament development and use. The benefits would more than offset the reduction in national service men. Industry will now have more young men available; there is no reason why the armed forces should not become more effective in spite of their loss.

The services are judged, quite rightly, by their power to deter a potential aggressor. But if their power in that respect fails—either because of their unpreparedness or because of the folly of an unthinking enemy—then they are judged by their ability to prosecute war. In that event their demands on the engineering industry are multiplied enormously. And the engineering industry is expected to meet these demands without any prior briefing. No wonder there were delays in 1914 and 1939. The services, presumably, always have in-the-event-of-war plans ready to be implemented. Industry should have similar plans, otherwise much of the current expenditure on armaments is potentially wasted. Only the Government can give the lead—by establishing machinery for periodic consultation between firms or groups of firms and the ministries, the services, Royal Ordnance Factories, and research establishments.

These two proposals are fundamental and widespread in their effects. They are therefore almost certain to be ignored. The little changes are made because in a complex society they are the only changes which can occur without being stopped by the friction they create. The big changes require powerful advocates to press them through the friction of general unconcern and the high spots of stiff opposition. There are always some men of this calibre in Britain. It is to be hoped that one of them to-day will be sufficiently far-seeing to press these much needed reforms. There is no peace in war but there is, or should be, war in peace—battles being fought to re-align the defence organisation to suit modern conditions. For individual engineers, or individual firms, these issues are rather remote—or so they seem—but in fact the difficulty of filling vacancies, and the drain on resources due to defence (like all the best drains it is very large and is buried out of sight) make these reforms specially important. Perhaps they will not be ignored.

Weekly Survey

Cover Picture. *The Royal Albert, the Royal Victoria, and the King George V docks together form the "Royal Docks"—the largest docks system in the world. The Royal Albert has 84 acres of water area and 3½ miles of quays, with a maximum depth of 34 ft. in the dock. It was opened in* 1880, *and was then subjected to the same process of amalgamation as all other London docks before the creation of the Port of London Authority in* 1909.

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Winter Fuel Gathered

The season of winter woollens and central heating is almost with us and much is being heard, including some discordant notes, about fuel supplies. A glorious summer has played its part in building up what appears to be "safe" stocks of coal: consumption has been abnormally low, open-cast output abnormally high—20 per cent. above the level during the summer of 1954. Despite the rail strike, mining disputes—through which 2 million tons of coal were lost in the first half of the year—and a disturbing failure on the part of the Coal Board to secure a higher output of deep-mined coal, distributed stocks are high enough to embarrass coal merchants. They are expected to exceed 18 million tons by the end of this month compared with 15½ million tons a year ago. A major and expensive contribution to this happy state of affairs were 8¼ million tons of imported coal in the first nine months of the year, at a cost of over £47 million.

The margin of safety in the country's coal stocks may have been increased, much more than is apparent, by the recent large increase in prices. The Central Electricity Authority and the Gas Board followed suit, and in the case of the C.E.A. the increase was by a sufficient margin to allow the building up of reserve for capital development. All this has given the oil industry a wonderful opportunity for expanding sales of fuel oil and paraffin, and they have not been slow to take it. Industry's consumption of black oil rose by 700,000 tons in the first half of this year—a rise of 23 per cent. on 1954. Sales of paraffin stoves have shot up and are only held back by a shortage of alloy steels needed for the manufacture of burners. There is little doubt that the campaign for smoke abatement has played into the oil companies' hands and there is every reason for being cheered by the prospects of cleaner cities. The same trend is evident in the United States where an increase of 50 per cent. in the number of blue-flame burners is anticipated in the next five years.

It is difficult to assess how far the swing away from coal will go, though consumption can hardly fail to increase. In the first half of this year, however, it rose by only 2 per cent. compared with a rise of about 6 per cent. in industrial output. The C.E.A's atomic power station programme cannot fail to accentuate this trend and it could be, therefore, that within relatively few years the N.C.B. will have to struggle to sell the full output of its mines at rising prices.

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Capital Cuts Coming

It is now evident that in the next stage of the fight against inflation, reductions in capital spending (the kind of spending in which the engineering industry is vitally concerned) will play a prominent part. Both at the Mansion House Dinner and at the Conservative Annual Conference at Bournemouth last week, the Chancellor of the Exchequer stated that certain proposals would be laid before Parliament when it reassembled which would further curb spending by all sections of the public.

Many ideas have been canvassed of recent weeks about Mr. Butler's concrete proposals for keeping the boom under control, and at the Bournemouth Conference he went some way to sketch his plans. In addition to a continued use of monetary means to keep expenditure down, suggestions include adjustments to the defence programme, less Government building, a halt to the road programme and a constant check on agricultural subsidies. It is therefore apparent that capital outlay at these key points will possibly be affected—defence, roads and building. These cuts are likely to be particularly effective because they are specific items and easy to carry out. The bold expansion plans of springtime have clearly wilted at the end of a hot summer.

How serious the cuts may be will not be clear until the Government's proposals are debated in the House of Commons. How long they will last will depend above all else on the success of the general restriction of credit. When the pressure on consumer goods and the drain on the gold and dollar reserves ease off, the capital expansion programme may be restored fairly quickly, but it is likely to be next year before this is possible for it will take several months for the trend of domestic prices and the overseas balance of payments position to become apparent after these new restrictions are enforced. Altogether, it looks as though a programme of restriction on the outlay on capital goods in certain key sections will be in operation until the next Budget.

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Carriages and Wagons

The invitation to tender for large quantities of locomotives, wagons, carriages, wheel sets and other components published last week by the Indian Government (ENGINEERING, October 7, Advertisements, page 2) shows that India is making a great effort to rehabilitate and expand its inland transport facilities and that it is, as yet, far from being able to supply its own needs. This follows hard on the orders placed last summer for rolling stock worth nearly £60 million, a substantial proportion with Indian firms. In all probability British builders will receive their share, but if the prices paid for locomotives ordered in August are any indication of what the Indians are willing to pay, profit margins may be very small indeed.

The narrowing profit margins in the railway carriage and wagon industry were the subject of comments by Mr. John H. Beach, chairman of the Gloucester Railway Carriage and Wagon Company, Limited, in his statement to stockholders last week. This would seem to apply more particularly to export markets where, in Mr. Beach's words: "prices quoted from some countries suggest that their costs are considerably lower than those prevailing in this country." This is not to say, however, that British Railways are willing to pay any price—"prices are very firmly controlled"—for the very large numbers of coaches, wagons and railcars they are ordering from private builders under their re-equipment programme.

Mr. Beach complained that the steel situation "still causes some anxiety, aggravated as it is by labour unrest" and tends to make it difficult to quote competitive delivery dates. In fact, the situation in the railway carriage and wagon industry is typical of present-day engineering; the shortages and attendant high costs make it difficult for British builders to compete abroad. Meanwhile, foreign competitors from Germany and Soviet Eastern Europe, who are so far relatively free from such handicaps, forge ahead and gain ground in the best British markets, among which India is traditionally one of the largest.

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Test for German Competition

The British engineering industry is vitally interested in the steps which Germany is about to take to offset the dangers of inflation. It is common knowledge that the comparatively rapid increase in wage costs in the British engineering industry has more than offset the advantage it has in the cost of its raw materials when competing with German industry in foreign markets. Until recently, Germany had not been faced with the more acute phases of full employment, but now Western Germany joins the United Kingdom as an economy where there are more jobs than men.

Herr Fritz Schäffer divulged last week that plans are being formulated to slow down the rate of German industrial expenditure and to reduce the domestic price level. The measures contemplated are a possible new tax designed to persuade industrialists to postpone the extension of their plants, and a curtailment of public expenditure on building. It is interesting to note, however, that so far as the general public is concerned, the German Government are considering reducing indirect taxation and granting higher tax-free allowances on lower incomes. If these plans should mature, the country will have followed almost in the same steps as the United Kingdom, for it would seem that public consumption is not to be discouraged and the full burden of restraint is to be borne by industry. At one time such a plan would have seemed to be on the right lines, for when resources are underemployed the best way to stimulate activity is to expand the capital-goods industries. Of late, however, the United Kingdom has discovered that the reverse of this in times of full employment may not be true, and that it may not be a satisfactory policy to concentrate the cuts on capital goods. It is only too clear in the last 12 months that the pace of expenditure in this country has been set by the consumer goods industries and this is a lesson which the Germans might well learn. This policy of stimulating consumer demand at the expense of the capital goods industries has already been challenged by Herr Berg, the chairman of the Federation of German Industries. It is too soon yet to say that Germany will not learn from British experience in curbing inflation, but if this should be so the edge might be taken off German competition in export markets.

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Painting Structural Steelwork

That the conventional priming paint consisting of red lead in linseed oil does not always give the best available protection to structural steelwork is becoming increasingly evident from the results of four long-term investigations begun jointly by the British Iron and Steel Research Association and the British paint industry between 1945 and 1948. By now, the experiments have begun to yield results and certain valuable practical conclusions can be drawn from them. These are contained in the third interim report of joint panel J/P 1 of the British Iron and Steel Research Association, entitled *Painting of Structural Steelwork*, obtainable, price 5*s*., post free, from the Association, 11 Park-lane, London, W.1. It may be of interest to recall that the first and second interim reports were published in December, 1946, and July, 1949, respectively. The present report covers investigations involving priming paints made from a variety of pigments and media, protective paints based on tars and bitumens, and also metallic coatings and methods of surface preparation. Many hundreds of test specimens have been prepared and are being exposed at Brixham, Devon, which provides a mild sea-side atmosphere having long periods of sunshine, and at Derby, situated in a severely corrosive industrial atmosphere. Mild-steel plates, 15 in. by 10 in., have been used throughout as specimens for receiving the various coatings.

The tests have shown clearly that, within the range of formulations tested, the paints containing aluminium powder were better than those containing zinc. Eight paints containing aluminium in alkyd medium gave protection equal or superior to that given by the standard red-lead primer. Moreover, they are lighter, more stable in the can, flow more readily under the brush, dry more quickly and form a harder film than the red lead in linseed oil priming paints. Moreover, when zinc oxide is used as the blending agent, the paints are non-toxic and can therefore be applied by spraying.

After six years' exposure, none of the sprayed or hot-dipped zinc or sprayed-aluminium coated specimens had failed by rusting to any significant extent. There were indications, however, that hot-dipped terne plate, 1 mil. in thickness, was less satisfactory under paint than aluminium or zinc coatings of 3 mils.

Of the 54 protective paints with tar or bitumen bases studied, one of the best two-coat schemes was one using paints containing natural bitumen (Gilsonite) and dehydrated castor oil (2 : 1) in white spirit. This showed no sign of rust after six years of exposure at each site.

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Australia's Choice

Countries, like individuals, are prone to live beyond their means. The temptation for countries is particularly strong in times of full employment. Many Western European states, including the United Kingdom, are troubled with this complaint at the present time but a similar situation has become chronic in Australia. Much publicity has been given in recent weeks to the decision by the Australian Government to cut imports as a means of defending the country's foreign exchange reserves. It has been clear for some time that a combination of lower export prices (notably for the wool clip) and a determination to press on with industrialisation would place an intolerable burden on the country's resources. In any event, the recent crisis in the balance of payments position has become a question of whether Australia would use monetary control, import restrictions or a combination of both. It has been decided to base the cure on import restrictions. Total personal incomes increased by 4 per cent. over the year while personal consumption increased by 9 per cent.—an increase which was accompanied by a serious reduction in personal savings.

The statistics show quite graphically that the trouble is over-spending. The controversial issue is whether import restrictions are the right solution. They have the advantage that they give a planned concrete reduction in overseas expenditure and so bring relief immediately (on paper) to the balance of payments position. However, experience the world over has shown that planned import cuts have an awkward habit of not taking place on the scale originally intended. Most countries are increasingly using monetary methods to overcome balance of payment difficulties. Australia is in danger of having contracted a fashionable complaint but using unfashionable methods to cure it—methods that have been remarkably unsuccessful in the past.

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Workhorse of the Air

There is now another claimant to the succession of the venerable D.C.3, whose gradual retirement after 15 years of service under every type of adverse condition has left a gap in the Western air fleets, estimated by Mr. Peter Masefield at some 600 aircraft. The newcomers, the Frye Corporation, Fort Worth, Texas, are headed by Mr. Jack Frye who was one of the men principally responsible for the design of the D.C.3 and who is assisted by Herr Kurt H. Weil, creator of the Junkers JU52. The result of what Frye describe as a long search not only to replace the Dakota on short hauls but to extend economical air transports to countries "where it is impractical to provide or maintain airports of the kind required by existing equipment," is a substantially bigger aircraft.

The claims for the Frye Transport are as follow: it will operate in airports of about half the size required by a D.C.3, "on relatively soft and unimproved airport surfaces with only 50 per cent. tyre loading of the D.C.3"; it will have a seating capacity of 50 to 60 people, a pay load of approximately 10,000 lb. and a cargo space of 400 sq. ft. The aircraft has been designed to incorporate either four 600 h.p. piston engines or four 850 h.p. turbo-prop engines. The outstandingly slow landing and take-off speeds, probably its most interesting feature, result from a wing loading of only one-third to one-quarter of the latest transport planes. Operating range is 250 miles and the cruising speed 150 m.p.h., though improved figures are expected from the turbo-prop version. Finally, "all major structures should operate without replacement for at least 15 years and 50,000 hours in the air."

If it were not that the Frye aircraft is still at the drawing-board stage, it would seem to be a formidable competitor to the Handley Page "Herald," which recently made its first flight and for which the company have already taken 29 orders for delivery 28 months ahead. The Frye is offered at a price of £124,000, compared with £134,000 for the Herald, but since no details have yet been announced of the cost per passenger-mile and per ton-mile, it is difficult to make valid comparisons. The fact that Fokker have decided to wait until the Rolls-Royce turbo-prop engine becomes available in 1958 before finalising their all-purpose aircraft, suggests that the choice of the power unit may be a deciding factor in operating costs. It would be interesting to hear these manufacturers' estimates of the demand for short-haul aircraft: they may well be considerably in excess of Mr. Masefield's figure.

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P.E.R.A. on Automation

The new developments in electronic control and automatic machining, although primarily of interest in large-scale manufacture, have certain features which may well lead to substantial changes in method when applied to firms engaged in batch production. In particular the use of electronically-controlled machine tools or of automatic inspection methods may be found suitable to small quantity production, provided that the range of products manufactured is reduced by specialisation and standardisation of components.

A proposal of the Production Engineering Research Association to carry out a programme of research on "automation," with particular reference to small firms, is therefore laudable. It is impossible, however, not to have doubts about the direction of this research after reading the memorandum on automation circulated by the Association. The word itself is used to cover such a variety of technical changes in production methods, including automatic jigs and fixtures, transfer devices such as chutes and hoppers, fork-lift trucks, conveyors and improved layout of equipment and operation sequences, as to be almost meaningless. The subjects which it is proposed to study include handling equipment, utilisation of automatic machines and equipment and techniques used to reduce or eliminate manually-controlled assembly operations. It is disappointing to find that the only research to be carried out consists of a survey of published information and trade literature and observations in selected firms in this country and abroad. No doubt this is a useful piece of information gathering, but to designate it "operational research" is to display an appalling ignorance of the real meaning of that term.

There is considerable scope for serious research into the technical, economic and human problems of the application of automatic control systems to batch production; but it will require a much more scientific approach than seems here to be envisaged. It is to be hoped that this programme is only the precursor to a serious study of the problems involved.

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Concrete Information from Russia

Among the spate of Soviet delegations picking up "know how" in this country, there has recently been one studying building methods, headed by Mr. V. A. Kucharenko, a vice-Premier of the U.S.S.R. and chairman of the State Committee for Construction Affairs. On a visit to the Hounslow factory of Concrete, Limited, the delegation saw the manufacture, under fully mechanised conditions, of prestressed concrete floor beams. They were given details of manufacturing cost breakdowns, output at the firm's four factories and a description of the use of Bison moulds and pneumatic cores during the manufacture of prestressed hollow concrete floor slab units.

In return, some information was given about production methods in the new Russian automatic factories producing pre-cast concrete building components. These components are chiefly flooring and walling units and there are already two factories of a fully automatic nature in the Moscow region. Eventually, it is claimed, there will be a hundred automatic factories of this kind in Russia, with the larger factories each capable of producing the equivalent of 700,000 square yards per annum. Prestressing and other manufacturing processes are mechanised and are operated from central control panels, but the cleaning of moulds and handling of units into the stocking yards are by normal methods. It appears that automatic production is by the individual mould method: a nest of moulds is mounted on a truck and presumably stressing is carried out using the moulds as abutments. The truck moves along a conveyor track from the setting-up point and from the stressing point to the concreting point, then to the curing point and so out to the stacking point. Something was also learnt about Russian methods of compaction by vibration.

Mr. Kucharenko has promised to give a copy of a Soviet film on the production of prestressed concrete building components to every British factory visited by the delegation, and he offered to show everything to anyone who cared to visit the Soviet Union.

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A Right Misused

The action of the Government in warning off participants in the Conference on Regional Planning and Development (the conference was reported in ENGINEERING last week) has some unpleasant implications. Not only were civil servants in the direct employ of the United Kingdom Government prevented from attending, but a number of officials from Colonial Territories, even those on the verge of independence like the Gold Coast, withdrew. A hint from the Foreign Office was sufficient to cause the American Embassy to bring pressure on Americans not to attend; the Norwegian Government stopped one of its officials from presenting a paper, and Dr. Olivetti was persuaded not to attend with his colleagues to read his.

Perhaps the most alarming aspect of this extraordinary affair was the readiness with which private individuals—business men and research workers supported by powerful independent foundations—accepted the hints they received from their respective Governments instead of standing by their own independent judgments. Although no British professor appears to have been frightened off, a number of British research workers were heard expressing fears that their attendance would jeopardise their chances of getting an American visa in the future. It is perhaps not surprising, after the views expressed in this country about some of the extremes of the American security programme, that the American Embassy should have thought that there must be something seriously wrong for the British Government to act as it did. In fact the Government's fears appear to have been without foundation.

No one would deny the right of the Government to prevent its servants attending undesirable conferences or trying to prevent such conferences being used for subversive purposes; but the enormous influence on freedom of inquiry and discussion which the exercise of that right to-day exerts, implies a duty not to use it without the most scrupulous care and in the most serious circumstances. In this case the impression made on visitors from abroad was disastrous.

THE MOTOR-CAR COMPONENTS INDUSTRY

(1) A FORECAST OF EXPANSION AND CHANGE

During the past three months ENGINEERING has conducted an inquiry among manufacturers of motor vehicle components and accessories to assess the impact on this large and varied industry of the expansion schemes of the motor manufacturers. These schemes amount to an increase in capacity of about 50 per cent. by mid-1959 on the 1954 output figure; that is, an output of 1¾ million cars, vans, lorries, buses and tractors.

One of the main difficulties in surveying the components industry lies in defining its boundaries; another lies in the very large number of firms involved. The current issue of the buyers' guide published by the Society of Motor Manufacturers and Traders lists 650 suppliers of "motor components and accessories" who are members of the Society and supply the bulk of the motor industry's needs. Reliable trade estimates put the total number at well over 1,000. Most of the large component manufacturers supply other industries, particularly aircraft and cycle but also other sections of the metal-using industries. To bring the survey within manageable limits, ENGINEERING approached a sample of large companies which together probably account for over two-thirds of the estimated (by the Ministry of Labour) numbers of employees engaged in the manufacture of components, parts and accessories for motor vehicles, cycle and aircraft—in June this year the total was 171,000. The results are being published in two parts: the first, which follows, attempts to define and describe the industry and to discuss its main problems; the second, to be published next week, is by way of a commentary on the expansion schemes of individual companies and their place in the general picture.

70 PER CENT. BOUGHT OUT

The importance of motor component manufacturers to the motor industry can be gauged from a variety of figures. The Census of Production 1948 shows that the net output of car and commercial vehicle manufacturers is roughly 30 per cent. of gross output, meaning that 70 per cent. of the ex-works value of the vehicles consists of materials, parts and components purchased outside the industry. Some of this, of course, is raw materials, particularly iron and steel, processed by the vehicle builders themselves, but most of it consists of components and accessories, ranging from ball and roller bearings to a complete set of electrical equipment or an upholstered body.

Since the war, the use of unit construction (a reinforced body structure without a chassis frame) has led most large car manufacturers to acquire a body-building company; for example, British Motor Corporation acquired Fisher and Ludlow, Ford acquired Briggs Bodies, and in general the manufacture of car bodies became part of the manufacture of cars, though generally carried out in a separate works. In addition, the larger car manufacturers own or control other makers of components such as wheels, carburettors, radiators, castings, forgings, etc. It is generally accepted that 50 per cent. of the value of motor vehicle output now consists of "bought out" components; in addition there is a growing volume of spare parts and accessories sold to the motor repair trade wherever British cars are in use. Trade estimates put the latter at between £90 million and £95 million in 1954. The value of car, commercial vehicle and tractor output (including spares supplied in that year with the cars and those made by the vehicle manufacturers) amounted to about £550 million. On the basis that half consisted of bought-out components and accessories, the output of the motor components industry in that year would have totalled £275 million (for new vehicles) and, say, £90 million (spares supplied to the repair trade), in all, £365 million. These figures, of course, exclude the output of components and accessories for the aircraft and cycle industries, and for general engineering. It would be reasonable to expect the value of the industry's output of motor vehicle components and accessories to rise roughly in step with that of the vehicle manufacturers, and the output of spares for the trade to rise rather more than proportionately owing to the increasing number of vehicles on the roads. The value of output for new vehicles (at 1954 prices) would therefore be 50 per cent. higher, say £410 million, by mid-1959, and that of spares perhaps 65 per cent. higher, say £150 million. This would represent a substantial proportion of the output of British engineering.

NEW PLANT AND MACHINERY

So vast an expansion in so short a time must raise problems in the main raw-material supplying industries, such as steel and non-ferrous metals. It could also be expected to impose a severe strain on the country's labour resources. We are not concerned in this article with raw metals, though severe shortages are developing despite heavy imports. Replies to our questions challenged the popular conception that the increase in labour requirements will be proportioned to the increase in output. First, they suggested that there is some slack—and more is developing—in many works through the fall in armament work and orders for military aircraft. Second, and much more important, advances in mass production techniques and the advantages to be derived from larger-scale production are likely to raise productivity to such an extent that relatively few extra workers will be needed; probably an increase on the present labour force of between 15 and 25 per cent. to achieve the 50 to 60 per cent. increase in output. This will, of course, require a heavy investment in new plant and machinery, among which will be a substantial number of automatic transfer machines. The amount considered necessary to keep up with the expansion of the vehicle manufacturers has been put by the industry at just over £100 million, compared with well over £150 million to be spent by themselves over the next five to eight years.

Employment in the motor vehicle manufacturing industry in June this year was about 283,000, arrived at by subtracting from the published figure 50,000 estimated to be employed in the cycle and motor-cycle industries. On the same date, the estimated numbers employed on the manufacture of components and accessories, which do not include bearings and tyres, was 171,000. Our inquiries within the industry suggest that the numbers employed in supplying aircraft and cycle firms is not substantially greater and may be less than the number employed on the manufacture of components not classified within the industry, such as tyres and bearings. It is probable therefore that on that date the total number of employees was between 170,000 and 180,000, giving a total labour force in the motor-vehicle industry of not less than 453,000. This compares with about one million employees in the American industry, where output of vehicles is roughly five times the British.

TWO-SHIFT WORKING

This startling difference in productivity is reflected in the relatively very low ex-works prices of American cars, which are not much more than half the corresponding British unit price. The industry say that this immense advantage held by the American manufacturers results entirely from larger production runs and appropriate labour-saving machinery, not worked less than two shifts. It does suggest, however, that the British industry can derive immense benefits from increased volume of output such as is proposed over the next four years or so. In this the components and accessories industry has a major part to play since it accounts for well over half the total value of the output of the motor industry as a whole.

One of the weaknesses of the motor components and accessories industry is the relatively small size of factory and a lack of concentration, except in the case of companies which supply the bulk of the industry's total needs. On the one hand this tends to prevent them from putting through large runs of standard items, on the other it exposes them to heavy pressure on the part of motor manufacturers to reduce prices till profit margins are cut to the bone, with a consequent inability to invest in modern plant or for that matter to invest in greater capacity. It is these firms, which constitute a very large proportion of the total number in the industry though a relatively small proportion of total output, that are most exposed to current shortages of labour and materials.

SEEKING NEW PRODUCTS

For this reason concentration is growing in the components industry and, side by side, small, medium and even large manufacturers seek assiduously new products which would lessen their dependence on the motor-vehicle manufacturers. There has been rivalry between companies such as B.M.C., Ford and Vauxhall, forcing profit margins down all the time in the component industry, and now the growing competition for overseas markets—from Volkswagen and others—is putting yet another premium on low production costs. The comments of two relatively large firms are typical:—

1. *E.N.V. Engineering Company, Limited.*—"The automobile industry is faced with formidable competition in the export field and as much of our business comes from this industry and as suppliers of components, the effect of this competition could become increasingly serious. Our company is enlarging the scope of its activities in the direction of industrial gearing, for which we anticipate a growing market. The spread of mechanisation continues and we are constantly investigating and finding new markets for products."

2. *Glacier Metal Company, Limited.*—"Examination of the reports of a number of companies manufacturing component parts of vehicles and machinery indicates that, though profits earned by those who make and assemble vehicles and machinery have shown substantial increases, many of the component suppliers have not found themselves in a similar fortunate position. The trading results of those of our competitors which are available to us show reductions in profit as against previous years. It may be that the trend towards the concentration of motor-vehicle building into a smaller number of bigger units has increased the buying power and, therefore, the pressure which such concerns can bring to bear upon component suppliers. The fact is that (in spite of brisk demand) increased investment, technical advance and increased efficiency have merely maintained our position without material increase of profit."

Despite these handicaps the industry is busy putting through its expansion schemes. The fixed assets of the leading companies have increased by an average of some 20 per cent. during the past two years, and there would seem to have been no lack of enterprise in following the motor manufacturers' lead. The expansion schemes are going forward smoothly enough, but the developing shortage of steel and, in some areas, of labour, are threatening to affect output. In the next article we shall describe how individual companies are tackling these problems. One dominant impression emerges from the material to hand: there is no discordant note concerning the expansion schemes; all appear to share the confidence of the leading vehicle manufacturers in the industry's long-term prospects.

SHIPBUILDING AND PROSPERITY

Clyde Dock Schemes discussed at "James Watt" Dinner

The importance of a proposed dry dock for the lower reaches of the Clyde; continued prosperity in the shipbuilding and engineering industries; and the dangers of increasing specialisation were three of the subjects dealt with in speeches delivered at the "James Watt" Dinner, held at the Central Hotel, Glasgow, on Thursday, October 6. The occasion was the annual dinner of the Institution of Engineers and Shipbuilders in Scotland and the President of the Institution, Professor A. M. Robb, D.Sc., of the faculty of Naval Architecture, Glasgow University, occupied the chair. Professor Robb proposed the toast to "James Watt".

The toast "Engineering and Shipbuilding" was proposed by The Rt. Hon. Viscount Runciman, O.B.E., A.F.C., D.C.L., President of the Institution of Naval Architects, who remarked that the two subjects of the toast had probably contributed more to the civilisation of to-day than any other activities. It was noteworthy that the decline of slavery and the growth of engineering took place in the same century.

Two points, which concerned both engineering and shipbuilding, came to mind: firstly, both were enjoying a high degree of prosperity, and secondly, in each there was a tendency towards increased specialisation. He felt that a reduction in prosperity might be beneficial. If there were more competition in both trades, if firms had to fight hard for contracts on price, the customer might "get his ship sooner and know what he would have to pay for her when he got her." Prosperity was nearly as corrupting as power, and if the discipline of competition returned in 1960, say, there would be nobody left with any experience of it.

A second aspect of modern shipbuilding and engineering industry was the trend towards specialisation, and consequent narrowing of outlook. One could buy specialists more cheaply than men who could think clearly about general questions, and he urged the institutions to do what they could to introduce more general papers and discussions into their proceedings.

A LESSON FROM 1929

In his reply to the toast, Sir James M. McNeill, K.C.V.O., C.B.E., LL.D., F.R.S., past-President of the Institution and deputy chairman of John Brown and Company (Clydebank), Limited, said that the shipbuilding industry had had ten years of prosperity and one year of recession, but now order books were filling again and immediate prospects were reasonably good. An analysis of the position ten years after the first World War underlined the desirable industrial policy for to-day. In 1929 a crisis had occurred owing to a fall in production—no doubt accentuated by currency and financial stresses. Hence we should now endeavour to increase production in all export items and sustain an expanding market at the market price level. The reopening of Far East and South American markets would help to establish a stable economy and to ensure peace.

Sir James also referred to the proposed new dry dock for the lower reaches of the Clyde, which, he said, would be of supreme national importance. A site had already been selected and the dock would be suitable for the largest vessels. If this project were carried out it would create considerable additional employment, and the further provision of a deepwater quay for ocean liners would help in the development of the tourist traffic. The proposals had received almost unanimous support from all the Clyde authorities, and would doubtless also receive the public's endorsement.

In responding to the toast "Our Guests," proposed by Mr. E. L. Denny, B.Sc., Sir Hector Hetherington, K.B.E., M.A., LL.D., Principal of the University of Glasgow, announced the introduction of a new course, the subject of which was nuclear engineering.

ENGINEERING AT CAMBRIDGE UNIVERSITY

MORE STAFF AND EQUIPMENT FOR RESEARCH

The Michaelmas Term at Cambridge opens with a Congregation at which the retiring Vice-Chancellor reviews the past academic year. This year, the Rt. Hon. H. U. Willink, Master of Magdalene, in his valedictory address before the installation of Professor Downs, Master of Christ's College, as the new Vice-Chancellor, referred to activities in the Department of Engineering which, though not perhaps radical changes, are matters of considerable importance. The most noteworthy were the plans to extend the engineering buildings on the Scroope House site by the construction of a fluid mechanics laboratory and the creation of new posts, in particular readerships in engineering.

These developments have been made possible because the University has been promised a grant of the whole of the cost without any diminution in the funds available for the other needs of the University as part of the Government's special programme for the development of higher technological education. It will be remembered that it was announced in the House of Commons on July 13, 1954, that in addition to the expansion of Imperial College, four universities—Glasgow, Manchester, Leeds and Birmingham—were to be given, through the University Grants Committee, additional grants so that they could increase their facilities for higher technological education, but the announcement was made before Cambridge University had had time to discuss the proposal. It is good news that Cambridge can now be added to the list.

The Engineering Department has for many years been one of the largest in the country. Before the first World War about 250 undergraduates were studying there; between the wars the numbers were between 500 and 550, and in 1954 they reached 688. It will surprise many to learn that in these periods engineers represented 7·2, 9·1 and 9·5 per cent. of the student population of the University.

Between the wars the Department devoted most of its energies to the task of primary importance—the teaching of undergraduates. After the second World War plans were drawn up and accepted by the University in 1946 for increasing the staff, buildings and equipment so that more attention could be given to research. In a very few years the teaching staff was doubled in numbers and a few research posts had been added. In 1949 the first building to be erected on the Scroope House site since 1931 was opened. It consisted of a new machine shop and an instrument shop, in which 61 craftsmen are now employed. Its erection freed space and enabled extensive improvements to be made in the teaching laboratories. In 1952 the second stage of building was completed, a five-storey block opened by the Duke of Edinburgh in November, 1952. This contains many research laboratories, lecture rooms and accommodation for teaching staff and research students, of whom there are now 40 working on a wide variety of engineering problems. The building to which the Vice-Chancellor referred will be the third, or more exactly the third and fourth stages of the post-war extension, since it will be completed in two steps. The first consists of a single-storey laboratory, eventually to be an extension of the structures research laboratory but temporarily to house the wind tunnels of the aeronautics laboratory, while a new four-storey fluid mechanics wing is being erected on the present site of aeronautics. In addition, there will be another three-storey wing to house the control engineering and servo-mechanism laboratory and additional research rooms.

More important than buildings are the men to work in them. Since the war, engineering research has increased in Cambridge (as it has in most other places) at such a rate as to tax the University's resources. Generous support has been forthcoming from industry and Government departments, but the new grant which has been accepted by the University will now enable research posts to be established, putting the activity on a more permanent basis. The most important—four readerships—were mentioned by the Vice-Chancellor. To these posts four lecturers in the Department—Messrs. A. M. Binnie, R. D. Davies, C. W. Oatley and J. H. Preston—were appointed last term. Dr. Preston has since resigned on his election to the Chair of Fluid Mechanics at Liverpool and Mr. H. G. Rhoden has been appointed in his place; it is hoped to fill a number of more junior posts during the year.

The new grant has already made other developments possible. On October 5 a new post-graduate course of instruction in control engineering began. Like the other post-graduate course in structures and materials which has been running successfully for four years, it is of nine months' duration and is intended for men with some years of industrial experience.

The developments in engineering science are so rapid that it is impossible to look too far ahead. There is little doubt, however, that the Cambridge engineering school is now being given facilities which will enable it to carry out efficiently its work of educating the undergraduate, training research students and furthering the advancement of knowledge for many years to come.

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Letters to the Editor

CONSTRUCTION OF BRITISH MOTORWAYS

Speed and Safety

SIR, May I make some observations on your Weekly Survey note relating to my British Association paper on Motorways (ENGINEERING, September 23). I hope that I did not contribute to the impression that hard shoulders are to be provided for occasional parking. I insist that hard shoulders should be provided, since they add greatly to the appearance, utility and stability of the carriageway, but I did emphasise that parking spaces must be provided well removed from the carriageway.

The second of your comments, applied to the "reduction in speed when in excess of 50 m.p.h." is somewhat answered by your later remarks about speed reductions from over 80 m.p.h. on the *Autobahnen* due to the lack of "summit vision." My experience last week when driving on the *Autobahnen*, an *Autostrada* and the *Lille Autoroute* confirms my opinion that a 50 to 70 m.p.h. speed range will cover most private vehicles, and 50 m.p.h. is about a mean speed for commercial vehicles. So I maintain my contention that complete safety must be provided for vehicles up to at least 50 m.p.h. and that safety at higher speeds will generally be provided on the Motorways.

Your last comment (that lack of control of building will lead to the ill-built shacks and untidy parking plots of the transport cafés) is obviously correct, but I hope that we shall not have to buy our petrol from only one combine on our projected Motorways.

Yours faithfully,
J. A. PROUDLOVE.

Department of Civil Engineering,
University of Liverpool.
October 5, 1955.

THE ELECTRICAL INDUSTRY

SIR GEORGE NELSON ON SOME TECHNICAL AND EDUCATIONAL NEEDS

The theme of the Presidential Address, which Sir George Nelson delivered to the Institution of Electrical Engineers on Thursday, October 6, was the prospects and responsibilities of electrical engineers in contributing to the future prosperity of mankind. It was inspired by the effects of growing population and increasing demand on the world's resources of materials, and stressed the necessity of a search for alternatives. Sir George also drew attention to the shortage of technical manpower and discussed methods by which this could be alleviated. We give below some extracts from his remarks.

PAST AND PRESENT

In his Presidential Address to the first meeting of the Institution—then the Society of Telegraph Engineers—in 1872, Charles William Siemens pointed out that what seemed to be separate compartments of science and engineering were really one, involving a vast range of problems in physics, applied chemistry, engineering and industrial management, developing into the whole field of electrical engineering as we know it to-day.

In 1905 the total generating capacity in Great Britain was 1,700 MW, or only 1/20 kW per head of population, while in June of this year it had reached 25,500 MW, or 1/2 kW per head of population—a tenfold increase. The capacities of individual sets in 50 years had risen from a few hundred kilowatts to over 100 MW and sets of 200 MW had been ordered. These developments had brought about a steady fall in the cost of electric power in comparison with the cost of living, and had been due to the imagination, courage and expenditure on research of the manufacturing firms.

SOME TECHNICAL DEVELOPMENTS

Although during the past 40 years the output of turbo-alternators had increased more than 20 times the rotor weight had gone down from 1·0 to 0·2 ton per MVA. By the use of grain orientation during the manufacture of silicon iron the power losses per pound of core iron in transformers had been reduced to one quarter of what they were 50 years ago; and the ratings had gone up from 5 MVA to more than 200 MVA with a rise in transmission voltage from 6 kV to 400 kV. Corresponding progress had been made in switchgear, the interruption ratings of which had risen from 25 MVA to 1,000 MVA. In the telecommunication field progress had also been staggering and the application of electrical and electronic control was increasing production and improving quality. An outstanding example was the rolling of sheet steel, which up to 30 years ago was produced from steam driven mills in small sheets at about 2½ m.p.h. To-day, it was manufactured with more accurate dimensions in coil lengths of 1½ miles leaving the rolls at nearly 60 m.p.h. The control of liquid and gas flow and of temperatures in the delicate processes of oil refining was another important field of application. Time was being saved and efficiency increased by using electronic computing machines to solve problems in research and design in many branches of science and engineering.

THE SEARCH FOR ALTERNATIVE MATERIALS

Although the exhaustion of conventional fuel was being counteracted by the generation of electric power from nuclear energy, it was not the only problem which had to be faced in meeting the need for an improved standard of living by a growing world population. It had been estimated that if the standard of that 90 per cent. of the population which was now below that of the United States and Great Britain was raised to the level of the latter overnight, the resources of basic materials, like iron and copper, would be exhausted in 25 years. Progress could not take place at that rate, but exhaustion might, nevertheless, easily become an acute problem in 100 years time, which was a short period in which to solve the problems of producing substitutes or basic metals synthetically.

Prominent in the field of substitutes were the cellulose products. Terylene fibres, for instance, had physical properties comparable with those of steel, indicating that means might be found of producing a substitute for that metal for structural purposes and making it possible to conserve iron ore for its magnetic or other special properties. A synthetic material had also been produced from which pipes for conveying hot, cold or corrosive fluids were manufactured, thus replacing copper or lead at a fraction of the price and with less liability to corrosion, and conserving two metals the supply of which was rapidly diminishing.

TECHNICAL MANPOWER SHORTAGE

While it was providential that science had put nuclear energy at the disposal of our statesmen it was hoped that they would be successful in convincing possible aggressors that war could not be contemplated. If they were successful it would be possible to release a number of scientists, technologists and engineeers to play their part in the improvement of world conditions. Such release would not, however, be sufficient to solve all the problems to which reference had been made and the Institution must therefore press for still greater facilities, in order to overcome the shortage of technical manpower. It was particularly necessary to attract a great proportion of the young people who still chose to pursue the Arts; and to further encourage those who took no steps to carry their technical education to graduate standard.

Interest could further be stimulated by increasing the numbers of qualified teachers in mathematics and science subjects and by explaining to those who had reached the General Certificate of Education level the opportunities of a career in scientific subjects. Facilities for awarding scholarships should be increased, the standards of technical colleges, not affected by the upgrading scheme, should not be lowered, and promising part-time students should be transferred to a sandwich or full university course. Careers masters should be able to push forward boys of special ability.

QUALIFIED MANAGERS

The demand for quantity must, however, not be allowed to lower the standards of quality. Nothing was further from the truth that the Institution was raising its educational requirements above what was necessary. There was an urgent need for technically qualified men with a gift for management. Such a quality was born and not made. The problem was to develop the natural gifts of a candidate in association with scientific and technical education, a course in which careers masters could do much to help.

Great Britain had few natural resources and its scientific technological and skilled people were its greatest economic asset. This being so they must be employed in the most efficient manner in order to obtain the lowest cost of production and to enable Great Britain to compete successfully in the world markets.

BRITISH WATCHES AND CLOCKS

A CRITICAL TIME

The exhibition " Five Centuries of British Time Keeping " held in the Goldsmiths Hall in London recently was a useful reminder of the former British supremacy in clock and watchmaking and of the efforts that have been made since the war to establish the industry in world trade. At a Press conference held on September 27 representatives of the industry outlined the progress made since the Government decided that the re-establishment of the industry on a sound commercial basis was a strategic objective and took steps to provide the necessary incentives. This was the result of the galling experience when war broke out that the country had practically no capacity for the manufacture of fuses and instruments which required the micro-engineering techniques found only in watchmaking. Germany had built up a large and prosperous industry with heavily subsidised clock exports. Facts given by Mr. M. L. Bateman, chairman of the British Horological Institute and joint managing director of Ingersoll Limited, and by Mr. Rex Smith, chairman of the Mechanical Clock Division of the British Clock and Watch Manufacturers Association and sales director of Smiths English Clocks Limited, indicate that substantial progress has been made.

In 1946 the Government restored an import duty of 33⅓ per cent. *ad valorem* on mechanical alarm clocks and provided £1 million for the purchase of machinery, which was allocated to selected firms on a generous rental basis with option to purchase after five years. Much of the machinery was purchased in Switzerland but the Swiss refused to supply the tools (mostly press tools) required for component manufacture, and these had to be made by the companies concerned. Craftsmen were trained initially around a nucleus of Swiss workers. The industry now employs some 17,000 people and output in 1954 totalled £10·2 million, made up of clocks (£4·9 million), watches (£3·9 million) and time recorders, etc. (£1·7 million). While this is a considerable increase compared to pre-war—in 1937 the industry employed only 4,000 people and had a gross output of £1·7 million—the advances made during the past two or three years have been relatively small, and it is clear that the industry is feeling the impact of foreign competition, particularly from German-made clocks. The progress made in the production of mechanical clocks has nevertheless been remarkable. Three companies—Smiths English Clocks Limited, at Wishaw, Westclox Limited, at Dumbarton, and John S. Francis Limited, at Fazakerley near Liverpool—are currently producing 4·3 million units of which nearly one third was exported, mainly to the Dominions. Exports of watches are a much smaller proportion of output —less than 4 per cent. in 1954—but the industry is able to supply the bulk of the needs of the home market for inexpensive popular-grade watches. Four major projects have been started since the war by Smiths English Clocks, the Anglo-Celtic Watch Company, Louis Newmark and Timex, who are together producing a wide range of watches at a rate of some 3 million a year. In the words of Mr. Rex Smith: " None of these projects has yet reached maturity but they have made remarkable progress in spite of difficulties."

The industry will have to expand the volume of output—and this means the volume of exports—very considerably if it is to stand on its own feet during the next five to ten years. Meanwhile it will require protection and probably some form of subsidy. This need is said to be recognised in official circles, " while the industry is being built up to full maturity." At present, one of the major handicaps is the absence of a well-equipped components industry: most of the components are made by the watch and clock

manufacturers themselves, and therefore on a relatively small scale. It is argued that the industry's output is much too small to warrant the setting up of a highly specialised components industry able to supply manufacturers, as is the practice in Switzerland. Whether such a development is possible without considerable wastage of existing production facilities is difficult to assess; but if it does not take place it is equally difficult to visualise an industry able to compete in foreign markets, either with the German and American clock industries or with the Swiss and French watch industries. The argument that such a step would reduce competition between the principal manufacturers, admitted to be "gentlemanly" within the British Clock and Watch Makers Association, is unconvincing—particularly if the parallel is drawn with the British and American motor industries. At present only one major producer, Timex Limited, are outside the Association.

The time may well have come for an objective report on the industry's organisation and prospects, which should include a survey of the retail organisation. This would help the Government to determine how much help should be given, and in what form. In the past, British inventiveness in this field has been remarkable, including the jewelled-lever watch, the "automatic" wrist watch, the first reliable ships' chronometer, the first "free pendulum" clock and the pioneering of synchronous electric clocks. There is a National College of Horology supported by the Government and the industry which is now supplying first-class technicians and craftsmen, and the National Physical Laboratory is also contributing most usefully to the knowledge and experience being built up. The caesium atom vibrator recently developed by the N.P.L. provides a means of checking chronometric instruments to an accuracy closer than a second a year. It would be short sighted therefore to allow the valuable gains made since the war to go to waste, but equally it would be inequitable to assist the industry, at the taxpayer's expense, to follow a path to maturity and economic independence which is not the most direct and the most likely to succeed.

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PERSONAL

MR. R. W. STUART MITCHELL, M.Sc., A.R.T.C., A.M.I.C.E., M.I.Mech.E., has been appointed group chief engineer of Associated British Engineering, Ltd., 9–10 Cavendish-square, London, W.1, comprising the Bergius Co. Ltd., British Polar Engines Ltd., Henry Meadows Ltd., A. C. Morrison (Engineers), Ltd., the Parsons Engineering Co. Ltd., and H. Widdop & Co. Ltd.

LORD BILSLAND, K.T., M.C., chairman of the board of directors of Scottish Industrial Estates Ltd., has tendered his resignation to the President of the Board of Trade owing to the pressure of other calls on his time. COLONEL HUGH B. SPENS, C.B.E., D.S.O., D.L., the vice-chairman of the company has also resigned. The President has accepted these resignations with regret and has expressed appreciation of the services rendered by these two gentlemen since the formation of the Estates Company in 1937. SIR ROBERT MACLEAN, C.A., has been appointed chairman in place of Lord Bilsland.

MR. WHITNEY STRAIGHT, C.B.E., M.C., D.F.C., is joining the board of Rolls-Royce Ltd., Derby, on November 1. He will take over the duties of executive vice-chairman from MR. A. G. ELLIOTT, C.B.E., on January 1, 1956. Mr. Elliott who is retiring at the age of 66 has had a long and distinguished career with the firm.

SIR ERNEST SMITH, C.B.E., D.Sc., F.R.I.C., M.Inst.Gas.E., F.Inst.F., has accepted an invitation to serve as President of the National Smoke Abatement Society, Palace Chambers, Bridge-street, London, S.W.1, for a further year, in view of the death of the President-elect, LORD HORDER.

MR. A. G. HIGGINS, M.Sc., F.R.I.C., F.I.E.S., Barrister-at-Law, took office as President of the Illuminating Engineering Society, 32 Victoria-street, London, S.W.1, on October 11.

MR. JOHN V. SHEFFIELD, deputy chairman of Horseley Bridge and Thomas Piggott Ltd., Horseley Works, Tipton, Staffordshire, has been elected chairman in succession to the EARL OF DUDLEY, M.C., who, as stated on page 446 of our issue of September 30, has retired from the position though continuing to serve as a director.

The Ministry of Supply announce that MR. F. S. BARTON, C.B.E., M.A., B.Sc., F.Inst.P., M.I.E.E., has been appointed adviser, defence supplies (Ministry of Supply), to the United Kingdom High Commissioner in Canada. DR. D. H. BLACK, M.Sc., F.Inst.P., has been appointed principal director of electronics research and development, in succession to Mr. Barton, and DR. W. H. WHEELER, B.A., D.I.C., will succeed Dr. Black as head of the United Kingdom Ministry of Supply Staff, Australia, and scientific adviser to the United Kingdom High Commissioner in Australia.

MR. W. C. YOUNG, M.I.C.E., M.I.Mech.E., A.M.Inst.W.E., at present water engineer and manager, Chelmsford Corporation, has been appointed engineer to the Hanningfield Water Joint Managing Committee which is responsible for the Southend and South Essex Waterworks Companies' joint £5 million reservoir scheme at Hanningfield, Essex. MR. A. L. DAVIS, A.R.I.C., at present chief chemist and bacteriologist to the Southend Waterworks Co. is appointed chemist. He is succeeded at Southend by MR. J. G. SLACK, A.R.I.C., with effect from January 1, 1956.

MR. W. A. ROBERTS, A.M.I.E.E., has been appointed regional engineer, Midland Region, British Broadcasting Corporation, in succession to MR. J. A. COOPER, B.Sc.(Eng.), A.M.I.E.E., who will shortly be retiring from full-time duties after 32 years of service with the Corporation.

MR. K. MILLS, secretary of Dowty Equipment Ltd., Cheltenham, has been appointed company secretary of Dowty Fuel Systems Ltd.

MR. A. E A. WRIGHT, T.D., A.M.I.E.E., A.M.I.I.A., a member of the firm, has joined the board of Prior Stokers Ltd., Prior Works, 1–3 Brandon-road, York-way, London, N.7. He is specially concerned with the manufacturing side of the business. Mr. Wright has also been elected a director of Sheet Metal Specialties Ltd.

MR. J. W. S. STRAUGHAN, M.I.Mar.E., has been appointed chief engineer superintendent of the British Tanker Co. Ltd., in succession to the late Mr. A. AITKEN.

MR. F. W. SWINNEY, general manager of the furnace division of the International Furnace Equipment Co. Ltd., Aldridge, Staffordshire, has been appointed a director of the company.

PROFESSOR H. F. TAYLOR, professor of metallurgy and director of the foundry laboratory of the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A., has been appointed to the newly established American Brake Shoe Company Professorship of Foundry Metallurgy.

MR. G. R. HEMBROUGH has been elected a technical director of C. M. Keyworth & Co. Ltd., a wholly-owned subsidiary company of Croda Ltd., chemical and paint manufacturers, Croda House, Snaith, Goole, Yorkshire.

MR. A. D. SMART, C.A., at present chief accountant, has been appointed secretary of the British Oxygen Co. Ltd., Bridgewater House, Cleveland-row, St. James's, London, S.W.1, as from October 1, in place of MR. H. COBURN, A.C.A., who relinquishes that post following his appointment of director and secretary of British Oxygen Gases Ltd.

MR. E. P. EDWARDS, of White House, 111 Newstreet, Birmingham, 2, has now joined Catmur Machine Tool Corporation Ltd., as Birmingham area sales manager.

MR. T. A. NASH has joined the British Central Electrical Co. Ltd., 6 and 8 Rosebery-avenue, London, E.C.1, as a sales engineer.

MR. J. E. ROBERTS, buyer in the purchasing department of Steel, Peech and Tozer, Rotherham, a branch of the United Steel Companies Ltd., Sheffield, retired on September 30 after 43 years of service. He has been succeeded by MR. F. RODGERS, who has been assistant buyer for some time.

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COMMERCIAL

THE MANCHESTER ASSOCIATION OF ENGINEERS have removed their offices from 20 to 18 Booth-street, Manchester, 2. The telephone number is now Central 1717.

J. H. FENNER & CO. LTD., Marfleet, Hull, have opened a new branch on the corner of Guildford-street and Bute-street, Luton. MR. E. C. BODDY is responsible for the branch.

The offices of the ELECTRICAL ASSOCIATION FOR WOMEN and of the WOMEN'S ENGINEERING SOCIETY are now at 25 Foubert's-place, London, W.1. (Telephone: GERrard 5212.)

B. O. MORRIS LTD., of Coventry, have concluded an agreement with HAMMOND MACHINERY BUILDERS LTD., Kalamazoo, Michigan, U.S.A., to manufacture their automatic and semi-automatic polishing equipment, including rotary and straight-line machines, under licence in this country. The production of the range of machines has commenced.

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, 148 Piccadilly, London, W.1, state that their office in the United States has been moved from Washington to New York, at 17 East 54th-street, New York City, 22. The Society's North American representative, SIR WILLIAM WELSH and his assistant, MR. D. B. MORREN, are now officiating from the new address.

THE DIAMOND BLOWER CO., LTD., announce that the expansion of their business has made it necessary to obtain larger and improved manufacturing facilities. In July, they purchased the FERRY ENGINE CO. LTD., Wharf-road, Woolston, Southampton, and a substantial reconstruction of these works is in course of completion. The combination of this company's skill and that of the Diamond Blower Company, now the parent company, will provide a broad base for technical development. The transfer of the Diamond Blower Company's production from their present factory at Brent Crescent, North Circular-road, London, N.W.10, is to be completed by tomorrow, October 15. After October 30, all inquiries should be made direct to Wharf-road, Woolston, Southampton. (Telephone: Southampton 48254) or to the London office: 26–28 Hallam-street, London, W.1. (Telephone: LANgham 5113–5114.)

The premises of MERRIMAN & HOWARD LTD., in Deansgate, Manchester, have been considerably enlarged. This has also provided the parent company, KERRY'S (GREAT BRITAIN) LIMITED, Warton-road, Stratford, London, E.15, with a Manchester office for their machine-tool division.

THE ABWOOD TOOL AND ENGINEERING CO. LTD., Dartford, Kent, have announced a reconstruction of the company. As a result, the business will be carried on, in future, by the new company, ABWOOD MACHINE TOOLS LTD. Directorship, management and assets will remain the same.

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CONTRACTS

Electric Transformers. The Aluminum Company of Canada Ltd. have awarded a further order to FERRANTI LTD., Hollinwood, Lancashire, for three 71,000 kVA single-phase generator transformers stepping up to 301,400 volts. These units will form the second 213,000 kVA bank of generator transformers to be supplied by Ferranti Ltd. for installation in the power station of the Alcan project at Kemano, British Columbia. The transformers will have aluminium windings. This order brings the total number of transformers supplied or under construction by Ferranti Ltd. for the Alcan project to 13 units of a total capacity of 648,000 kVA.

Radio Signal Generators. A £23,000 contract for signal generators has been secured by MARCONI INSTRUMENTS LTD., St. Albans, Hertfordshire, in conjunction with Svenska Radio A/B, from the Royal Swedish Air Board. Covering a range of 12 to 425 Mc. per second, the new amplitude-modulated generator has a calibration accuracy of 0·5 per cent., and has the merit that spurious frequency modulation is virtually non-existent, an essential requirement of the Swedish Air Board specification.

Motor Trawlers. The Boston Deep Sea Fishing and Ice Co. Ltd., Fleetwood, have ordered two Diesel-engined trawlers from the GOOLE SHIPBUILDING AND REPAIRING CO. LTD., Goole. The main dimensions of the vessels will be 130 ft., by 27 ft., by 13 ft. 9 in., and the engines, which will be of 938 b.h.p. at 250 r.p.m., will be supplied by MIRRLEES, BICKERTON AND DAY LTD.

Pass-Out Turbo-Alternator Set. An order for a 4,500 kW pass-out turbo-alternator set has been received from the Westfield Paper Co. Ltd., Bathgate, West Lothian, by the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2. The 3,000 r.p.m. direct-coupled machine will be provided with a surface condensing plant made by HICK, HARGREAVES & CO. LTD. The alternator is of the closed ventilated type, generating at 3,300 volts and designed for operation with a power factor of 0·8. The consulting engineers for the installation are J. D. CROZIER & PARTNERS LTD., London and Edinburgh.

TECHNOLOGICAL COURSES

ENGINEERING FIRMS ENCOURAGE TUITION IN SPECIAL SUBJECTS

An article in our issue of September 16 (page 365) dealt with the provision made for the production of technologists in technical colleges and schools, the term "technologists" being taken to describe youths educated to National Certificate or Higher National Certificate standard. That those responsible for the operation of the industries of the country appreciate the work of these institutions, and are glad to employ their products, is made evident by the almost universal practice of allowing apprentices to attend day classes once or twice a week. In many cases attainment of a National Certificate is expected from student apprentices; for instance, boys of sixteen years of age or over, who enter on what is termed the Junior Training Scheme of the Hackbridge and Hewittic Electric Company, and who are given facilities for attending day classes, are selected for more advanced industrial training if they gain a National Certificate in three years. The whole training scheme extends over five years.

ADVANCED TRAINING FOR SPECIALISTS

It is not only by encouraging technical study at the apprenticeship stage that industry is promoting the acquisition of technical knowledge and skills. Much is also being done to provide advanced training of a specialist nature. An example is furnished by courses of lectures on the design of welded structures, arranged by the Quasi-Arc Company, which will be given by members of the company's technical staff. Courses will be held during the winter in London, Glasgow, Cardiff and Bilston. A pamphlet issued by the Manchester and District Advisory Council for Further Education gives particulars of the extensive range of advanced lectures which are to be delivered during the winter in the Manchester district. The subjects covered range from steam turbines, through aircraft stressing to recent advances in power system protective gear. Various members of local engineering firms are participating in these lectures.

Advanced courses of this type may be of great value to those past the student stage and faced with the practical matters of industrial life. Even an honours graduate will find that his university educational course did not cover many of the problems of practice. Some, especially those engaged in certain types of research, will be likely to profit from the courses of lectures on the principles and methods of photoelasticity to be held at University College, London, in October and January. Courses of lectures of a very different type, and addressed to graduate chemical engineers, are to be held at the University of Liverpool in the 1955-56 session. The subjects covered are "Adsorption and Heterogeneous Catalysis," "Recent Advances in Organic Chemistry," and "Microbiology."

FIRMS PROVIDE LECTURERS

A number of courses of lectures on specialist subjects, to be held in the evenings, have been arranged at the Northampton Polytechnic. Many of the lecturers are staff members of commercial firms or research associations. Examples of the subjects covered are microwave technique, soil mechanics and foundation problems, fatigue of metals and mathematics, digital and analogue computing, and statistics. Another course of lectures intended for those in practice has been arranged by the National College for Heating, Ventilating, Refrigeration and Fan Engineering. The course which deals with process heating is described as designed for "engineers and contractors." It will be held at the Borough Polytechnic from the beginning of October onward.

This National College does not confine its activities to the provision of instruction for those responsible for the planning and execution of works coming within the range which it covers. A course of day and evening classes has also been arranged at the Borough Polytechnic for heating and ventilating operatives. It should be of particular value to potential charge-hands, foremen and supervisors. Some courses which have been arranged by Incorporated Plant Engineers should also appeal to some men falling within these classes, as they are directed to those interested in the installation and operation of plant, rather than its design and construction. The courses which are being held in Birkenhead, Birmingham, Blackburn, Dartford and Hatfield are planned for men who have reached the Ordinary National Certificate standard, but the holding of this certificate is not an essential condition for entry.

The extent to which men of the foreman and supervisor classes who wish to improve their knowledge and status, are catered for in London and the Home Counties is shown in an extensive list issued by the Regional Advisory Council for Higher Technological Education. This gives information about the courses to be held in technical colleges ranging from Brighton to Luton and from Gravesend to Wolverton. The courses offered extend from one leading up to the attainment of the Boiler Operator's Certificate of the City and Guilds of London Institute to others dealing with boiler house practice, combustion engineering, steam utilisation practice, fuel technology, technology of gas manufacture and supply, and solid fuel production, distribution and utilisation. Another course directed to those already engaged in industry which may be mentioned is one dealing with concrete practice to be held at the City and Guilds of London Institute. It is intended for "supervisors and potential supervisors engaged in concrete operations."

WORK STUDY

So much has been said and heard about the vital importance of an increase in industrial output, that it is natural to find some educational courses laying direct stress on the question of production. An example is furnished by a series of lectures under the title "The Use of Welding to Increase Productivity" which have been arranged by the British Welding Research Association. The lectures will be held in various industrial towns from October, 1955, to January, 1957. The reports of most of the productivity teams which visited the United States laid so much stress on the value of mechanical handling as a factor in high output, that the series of evening courses on materials handling and work study, which have been arranged by the College of Production Technology, may be classified as concerning the question of productivity. The courses consist of eight sessions, one session per week, and are being held in London, Glasgow, Sheffield, Manchester and Leeds between this month and the end of the year.

The term "work study" which forms part of the title of the above courses, also figures in the extensive series of residential week-end courses which are being held by the Institute of Industrial Supervisors. There are some 46 of these, all falling under the general title "Supervisory Development." In England, they are being held at Leamington, Buxton, Ilminster and Missenden and in Scotland at the Bridge of Allan. In addition to work study, the subjects covered include the foreman and cost reduction, the practice of supervisory management, human relations, communication and discipline and industrial law. These residential courses are, apart from the direct instruction provided, of particular value in giving opportunity for private discussions and the interchange of views and opinions between individual members. Directed to the same ultimate end, the improvement of productivity the Work-Factor Company has arranged a four-week course to be held in London in October. This is intended for the executives of industrial companies. The Work-Factor system is concerned with means of improving work methods and establishing time-study standard data. It enables labour costs and outputs to be estimated from samples and work flow to be organised economically on production lines.

The addresses of the firms, organisations, and institutions referred to in this article are as follow:—

The Hackbridge and Hewittic Electric Company, Limited, Hersham, Walton-on-Thames, Surrey.
The Quasi-Arc Company, Limited, Bilston, Staffordshire.
Manchester and District Advisory Council for Further Education, Deansgate, Manchester, 3.
University College, London, Gower-street, London, W.C.1.
The University of Liverpool, 9 Abercromby-square, Liverpool 7.
Northampton Polytechnic, St. John-street, London, E.C.1.
National College for Heating, Ventilating, Refrigeration and Fan Engineering, Borough Polytechnic, Borough-road, London, S.E.1.
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham.
Regional Advisory Council for Higher Technological Education, Tavistock House South, Tavistock-square, London, W.C.1.
City and Guilds of London Institute, 31 Brechin-place, South Kensington, London, S.W.7.
British Welding Research Association, 29 Park-crescent, London, W.1.
College of Production Technology, Charing, Ashford, Kent.
Institute of Industrial Supervisors, 24 Albert-street, Birmingham.
The Work-Factor Company, 26 Leadenhall Buildings, 1 Leadenhall-street, London, E.C.3.

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OPENING MEETING OF I.E.E. SESSION

The Presidential Address

The opening meeting of the 1955-56 session of the Institution of Electrical Engineers was held at Savoy-place, London, W.C.2, on Thursday, October 6, the retiring president (Mr. J. Eccles) being in the chair during the first part of the proceedings.

It was announced that Mr. C. T. Melling had been appointed an ordinary member of the Council in place of Sir Hamish MacLaren, who had been elected a vice-president.

The chairman presented the premier certificates for the papers read during the 1954-55 session and in doing so announced that the Christopher Columbus Prize for Communications had been awarded to Sir Gordon Radley and Dr. Kelly of the Bell Telephone Company for their work on the transatlantic telephone link.

Sir George Nelson then delivered his inaugural address as incoming president, an account of which appears on page 526 of this issue.

A vote of thanks to Sir George for his address was proposed by Colonel B. H. Leeson, who said that the President had peered into the future and had provided information of lasting consequence about the prospects of the engineering profession, the well-being of our country and the better living of people throughout the world. The job of scientists, technologists, technicians, Government, statesmen and the man in the street was clear. They had to produce more food and more materials. For the young engineer this was a pleasing prospect which offered opportunities for service and great adventure.

In seconding the vote of thanks, Sir Hamish MacLaren said that the President had made clear that we had no reason to rest on past conquests and many worlds to conquer lay ahead.

A vote of thanks to Mr. Eccles was proposed by Sir Harold Bishop, who called attention to the heavy burden of his presidential duties at a time when he was closely concerned with the development of nuclear energy for power generation. He had assisted in the formation of the British Nuclear Energy Conference and had, in fact, borne the brunt of the work in carrying it through. He had also spent a great deal of time in explaining the point of view of the Institution on technological education to the Minister, and if as a result they had not got all they wanted, a great deal of progress had been made.

Sir Gordon Radley seconded and Mr. Eccles briefly replied.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Portuguese East Africa (Moçambique). Overseas Economic Survey. By BRYCE J. M. NAIRN. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

Though a few industries are starting up in the Province, the author points out that it is highly unlikely that Moçambique will ever become industrialised, and highly probable that it will continue to be obliged to import the bulk of its consumer goods, of which the United Kingdom has always been a leading supplier. However, with the opening up and development of the territory the large native population is slowly evolving and developing a taste for a variety of cheap European consumer goods, and the spending power of the native is increasing. The survey gives some essential factors which United Kingdom exporters must take into account if they wish to maintain and develop their trade in this market.

Work Study. British Productivity Council Case Studies. *British Productivity Council, 21 Tothill-street, London, S.W.1.* (2*s.* 6*d.*)

In this pamphlet, 15 case studies are presented of British firms that have benefited from the introduction of work study. The industries concerned include cotton manufacture, electrical equipment, plant engineering, fabrics, factory layout, footwear, furniture, horticulture, hosiery, newspapers, office work, a one-off electrical equipment factory, printing, surgical dressings, toys and smallware.

The following reports are obtainable from the Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire:—

Investigation of Eye Movements of an Aircraft Pilot under Blind Approach Conditions. By A. F. A. WATTS and H. C. WILTSHIRE. Note No. 26. (5*s.*) Eye movement patterns were obtained of a pilot in an aircraft fitted with a standard R.A.F. blind flying panel on five approaches using standard beam approach. The patterns were obtained by photographing the reflection of the pilot's eyes in a mirror attached to the instrument panel. The results show the proportion of time spent on each instrument, the duration of the fixation time on each instrument, the frequency of the eye fixations, and the sequence of eye movements.

Vibration Characteristics of a Cantilever Plate with Swept-Back Leading Edge. By A. E. HEIBA. Report No. 82. (5*s.*) The paper presents an experimental study of natural frequencies and modes of vibration of uniform cantilever plates; 16 planforms were tested by combining aspect ratios of 0·8, 1·2, 1·6 and 2 with leading-edge sweep-back angles of 0, 15, 30 and 45 deg. Experimental values of the natural frequencies for the first six modes are given for each plate, together with the nodal patterns. The results have been plotted in frequency curves of the same family shape.

The effect of sweep-back on the frequency and on the position of the nodal line of a particular mode is more marked on high aspect ratio plates. The frequency of the flexural modes varies only slightly with aspect ratio.

A formula has been derived for calculating the frequency of a particular mode on a given plate, assuming the plate geometrically similar to one of the planforms tested but with different thickness and of different material, provided that Poisson's ratio for both materials are the same.

The Application of Sub-Sonic Vibrations during Solidification of Castings with Particular Reference to a Material for Gas Turbine Blades—"H.R. Crown Max." By S. HINCHLIFF and JOSIAH W. JONES. Report No. 89. (5*s.*) After considering the theoretical relations between the microstructures of castings and their mechanical properties, and the possible advantages of vibration during solidification, the authors describe experiments carried out in a melting furnace designed for use with a vibrator on H.R. Crown Max. alloy. Sillimanite bonded with ethyl silicate was used as a material for moulds to withstand vibration. From the results it is concluded that vibration produces a smaller and more equi-axed grain structure, and that the mechanical properties are improved. Poured at a temperature of 1,550 deg. C. and a frequency of 48 vibrations a second and an amplitude of 0·005 in., the following results were obtained. The corresponding figures for unvibrated specimens are shown in brackets. Ultimate tensile strength, 43·2 (37·2) tons per sq. in.; elastic limit, 21·5 (16) tons per sq. in.; elongation, 41 (33) per cent.; reduction in area, 36 (27) per cent.; balanced impact, 13 (9·6) ft.-lb.; grain size, 15 (3) grains per sq. in.

Report on the Machinability of Aircraft Steel D.T.D.331 (B.S.S.99) Using H.S.S. Tools. By J. CHERRY. Note No. 25. (5*s.*) The material investigated was a nickel-chromium steel with a tensile strength of 80 to 90 tons per sq. in. High-speed steel tools containing 18 per cent. tungsten and 5 per cent. cobalt were used throughout the tests. Basic tests conducted on a centre lathe showed that the best true rake angle was 15 deg. and gave the following results, for one-hour tool life:

Feed	Ratio of metal removal rate	Speed, ft. per min.	Surface finish, C.L.A. microinches
0·0025	1 (datum)	70	120
0·005	1·72	60	140
0·010	2·57	43	250
0·015	3·15	35	450
0·020	3·44	29	520

Volume removable per h.p. per minute, 1·1 cub. in.; h.p. to remove 1 cub. in., 0·91; vertical pressure on tool = 360,000 × depth × feed; Brinell hardness, 403; Meyer hardenability index, 2·18. Tests were conducted to seek a relationship for applying the basic life tests to cylindrical milling. When the maximum undeformed chip thickness was taken as the equivalent of the feed per revolution in turning, the life values showed closer agreement.

Manuel du Béton Précontraint. By VICTOR WEINBERG, with the collaboration of CLAUDE A. RIVIÈRE and YVES VALLETTE. *Dunod, 92 Rue Bonaparte, Paris, 6e.* (2,900 francs.)

This manual on prestressed concrete is designed to provide a practical planning and constructional guide to contractors, builders, architects, road and bridge engineers, planning offices in general and those of nationalised public services. For the purpose of drawing up projects the principle of the stresses involved is set out simply, it being made clear what constitutes pre-stress. The text of provisional official instructions, with precise and detailed explanations and guidance as to their practical use, the method and application of calculations for different clases of work together with tables, graphs and special formulae for prestressed concrete work are also given so that plans can be drawn up without special preparation. As far as executing the work is concerned, the author gives advice, based on 30 years' experience, which can be applied directly to work of this description with the least amount of trouble. The method of operation and examples of work carried out are described and there are statistical and graphical appendices as well as explanatory comments on technical instructions which have been issued on the subject.

La Couleur dans les Activités Humaines. By M. DÉRIBÉRÉ. *Dunod, 92 Rue Bonaparte, Paris 6e.* (1,980 francs.)

This book discusses colour in its relation to human activities of many kinds. After dealing with definitions, and terminology, it gives a system of classification of colours, discusses the visibility of colours, colorimetry, the relationship of light and colour, and the effect of colour on living things, including plants. A number of plates are included to show pleasing combinations of colours in workshops, offices and houses.

Méthodes d'Algèbre Abstraite en Géométrie Algébrique. By P. SAMUEL. Part 4 of Ergebnisse der Mathematik und Ihrer Grenzgebiete. *Springer-Verlag, Reichpietschufer 20, Berlin, W.35.* (23.60 D.M.)

This work constitutes part 4 of a series on mathematical results and their limitations published under the auspices of the Zentralblatt für Mathematik. It deals with abstract algebraic methods in algebraic geometry and is intended to provide geometricians with as complete an exposition as possible of the principles of the subject and to be of practical use to the reader.

Solar Energy Research. Edited by FARRINGTON DANIELS and JOHN A. DUFFIE. *The University of Wisconsin Press, 811 State-street, Madison, Wisconsin, U.S.A.* (4 dols.) (Reviewed on page 449, issue of September 30.)

Transistors and Other Crystal Valves. By T. R. SCOTT. *Macdonald and Evans, Limited, 8 John-street, Bedford-row, London, W.C.1.* (45*s.*) (Reviewed on page 489, issue of October 7.)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Chemical Nickel Plating. ALBRIGHT AND WILSON LTD., 49 Park-lane, London, W.1. "Kanigen" chemical nickel plate, a nickel-phosphorus alloy, which nickel plates a surface by catalytic action. No electrical contact is required, and articles can be plated by simple immersion. Kanigen will plate all surfaces with which it comes into contact, and can be used for intricate shaped articles. It can be applied to most of the metals used in engineering, and to plastics, ceramics and glass. Corrosion resistance, uniformity of thickness and adhesion are good, and the hardness of Kanigen can be increased by heat treatment. Illustrated brochure.

Unplasticised P.V.C. CHEMIDUS PLASTICS LTD., 89 Upper Thames-street, London, E.C.4. Chemidus 2,000 unplasticised p.v.c., available as rigid pipe, tubing, solid rod and welding wire. Easily welded, with excellent mechanical properties and chemical resistance. Free from toxicity. Folder containing leaflets on general characteristics, mechanical and physical properties, chemical resistance, permissible loading pressures for pipes, adhesive for use with unplasticised p.v.c., working and fabrication.

Aircraft and Ejection Seats. MARTIN BAKER AIRCRAFT CO. LTD., Higher Denham, Bucks. "The Story of an Enterprise"—26 years of Martin Baker Aircraft Co. Ltd. The first 15 years—prototype fighters of tubular construction; the last 11 years—ejection seats; other developments—balloon cable cutter, jettison hood for Spitfire, power jettisoning of hoods, ammunition-belt feed mechanism, wind indicator, propeller oiling unit. Handsomely-illustrated descriptive brochure.

Synthetic Rubbers. E.I. DU PONT DE NEMOURS & CO. (INC.), Wilmington, Delaware, U.S.A. Hypalon, a thermosetting elastomer comprising chlorosulphonated polyethylene, resistant to heat, oxidation and chemical attack; and Neoprene, a flexible, low-permeability, inert synthetic rubber. Two descriptive leaflets—"Facts about Hypalon," No. 1, and "Neoprene Notebook" No. 64.

Radar for Aviation. DECCA RADAR LTD., 1-3 Brixton-road, London, S.W.9. Radar link for remote display, storm-warning radar, special-purpose radar, fixed-coil displays, Q-band airport surface movement radar, air surveillance radar, defence radar, airfield control radar, glide-path radar. Eight illustrated leaflets giving descriptions and specifications.

Plywood Adhesives. AERO RESEARCH LTD., Duxford, Cambridge. Aero Research Technical Notes Bulletin No. 150. Production techniques with Aerolite K, KL and R adhesives for plywood manufacture, veneering, and filling. Illustrated descriptive leaflet.

Drilling Equipment. CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., Redruth, Cornwall. Hand drills, drifters, wagon drills, paving breakers, trench pumps, drill sharpeners and grinders, compressed-air equipment, etc. Catalogue giving brief description of range of Climax products.

Aircraft Instruments. SPERRY GYROSCOPE CO., LTD., Great West-road, Brentford, Middlesex. Flight instruments, automatic pilots, synchros and electronic components, integrated power controls, aircraft hydraulic pumps and motors. Descriptive leaflet.

Agricultural, Horticultural and Dairy Electrical Equipment. GENERAL ELECTRIC CO., LTD., Kingsway, London, W.C.2. Details of electrical equipment available for agricultural, horticultural and dairy equipment. Illustrated pamphlets.

Cleansing Tank. KINGSBOURNE PRODUCTS LTD., 216a, South Coast-road, Peacehaven, Sussex. Monarch pneumatic cleansing tank, employing paraffin spray as cleaning agent. Illustrated leaflet giving specification and method of operation.

Aluminium Foil Roofing. ALUMINIUM UNION LTD., The Adelphi, London, W.C.2. Aluminium foil for roofing—heat reflection and weather protection. Illustrated descriptive leaflet.

Mushroom Valve. MARTONAIR LTD., Parkshot, Richmond, Surrey. Four-port push-operated pilot valve, $\frac{1}{4}$ in. B.S.P., for pressures between 20 and 100 lb. per square inch. Illustrated leaflet.

Polythene Fittings. IMPERIAL CHEMICAL INDUSTRIES LTD., Witton, Birmingham, 6. Joint fittings for polythene tubes. Illustrated leaflet.

Display Stand. DISPLAYWORK LTD., 12-13 Henrietta-street, London, W.C.2. Wire display stands. Illustrated leaflet.

THE ACCELERATION OF NUCLEAR PARTICLES IN CURVED PATHS

CYCLOTRON, SYNCHRO-CYCLOTRON AND SYNCHROTRON

*By J. B. Adams**

This paper, entitled "A Review of Accelerating Machines for Nuclear Particles," was read before Section G of the British Association at Bristol on September 5, 1955. It gives an account of the natural occurrence of nuclear particles, and of man's attempts to produce them artificially. The first stage is the linear accelerator; a more detailed account of the development of linear accelerators was given by Mr. C. W. Miller in a paper entitled "Linear Acceleration of Charged Particles to High Energies," read on the same day and published in full in ENGINEERING *for September 9, 1955 (vol. 180, page 340). The next stage is the curved-path accelerator, which is followed from cyclotron through synchro-cyclotron to synchrotron.*

There exists a common misunderstanding that high-energy particle accelerators are directly connected with atomic energy and that their development is therefore helping to provide atomic-energy power stations. It is true that the lower-energy accelerators do play some part in the atomic-energy research programme, but the really high-energy machines have almost nothing to contribute to this programme. These machines are built to further research that has no immediate practical application. Nobody can say how the results of this work will affect atomic energy or any other branch of applied science in the future, and, for the moment, the results only increase our knowledge of the fundamental particles that go to make up our universe.

The discovery by Becquerel and the Curies that some substances, notably radium, emitted some form of rays or particles is common knowledge. When such a naturally occurring phenomenon as this is discovered it is inevitable that someone would build a machine to do the same job a little better. Cockcroft and Walton, working with Rutherford at Cambridge, built such a machine, a high-voltage set, and accelerated particles to an energy comparable with the natural sources. This was one of the first particle accelerators used for nuclear experimental work and with it many major discoveries were made concerning the internal composition of the nucleus of the atom. To proceed further with these researches, higher energy machines were soon demanded and those physicists with leanings towards engineering needed very little encouragement to start constructing bigger machines and to start thinking of new ways of accelerating particles.

By the time several machines had been built, another source of particles, of far higher energy than those emitted from such substances as radium, or obtainable from the machines, began to be examined in detail. These particles, however, did not come from any source on this earth but from outer space and they were therefore called the cosmic particles, or cosmic rays. In this case unfortunately, nature is not very prolific. The cosmic rays arrive continuously on the earth's surface, but at a rate that makes experimenting with them very tedious. Also they cover a very wide range of energies and are mixed in type, which adds further difficulties for the experimenter. The machine builders found themselves bracketed by the natural terrestrial sources, which they had already bettered, on the one side, and by the cosmic particles of energies far beyond the dreams of the most clairvoyant on the other. Even to-day, the largest of the machines is a long way from accelerating particles to the highest energies observed in the cosmic rays, but they have reached energies where it is possible to create particles that are only observed in cosmic radiation, the mesons and other "strange particles." Furthermore, these machines will give reasonably pure sources of fundamental particles all of roughly one energy and in very large quantities compared with the cosmic rays. Fig. 1 summarises the present state of the development of high-energy particle accelerators. On the left-hand side are noted some of the natural sources and the energy of the particles involved; on the right-hand side are listed the machines with their names and the energy of the particles they can produce. (For clarity only those machines accelerating the heavy particles, such as protons, are listed; the electron machines are omitted.) It is the object of this review to describe in very general terms the development of these machines, the ideas behind them and their practical realisation.

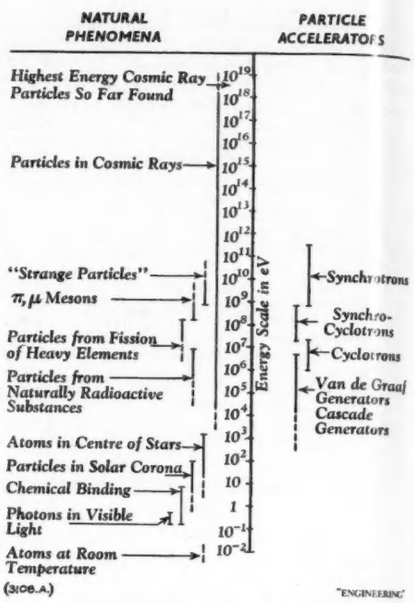


Fig. 1 Energies of nuclear particles from natural sources and from accelerating machines.

EARLY PARTICLE ACCELERATORS

The first attempts to accelerate charged particles to high velocities used high-voltage machines in which the total acceleration was given to the particles in one step. Charged particles were generated at one terminal of a high-voltage set and the electrostatic forces exerted by the other terminal accelerated the particles towards it. There is, of course, a definite limitation on the voltage that can be maintained in this fashion between terminals. If the terminals are standing on large insulators in air, it is difficult to maintain more than about 2 MV between them. If the whole machine is put into a high-pressure tank and run in an atmosphere of nitrogen and freon at high pressure, then 10 MV is the present-day maximum. Since the time when the first set for accelerating charged particles was built by Cockcroft and Walton, hundreds of machines using various principles, such as cascade generators and Van de Graaf generators, have been steadily developed as technology has improved. Although this type of machine is invaluable to nuclear physics, it is a blind alley as far as the development of higher voltage machines is concerned. The main limitation is the voltage breakdown of the insulator used in the set, either air or high-pressure gas. During the year 1928, Wideröe suggested accelerating the charged particles in steps, not trying to get the full acceleration in one stage but increasing the velocity of the particles continuously. Sloan and Lawrence in 1931 proposed a way of getting step-by-step acceleration by means of what is now called a linear accelerator or Linac.

Fig. 2 shows the essential parts of a linear accelerator. A charged particle starting at A is attracted towards the first tube when the voltage on the tube is of the appropriate sign. This same particle emerges from the first tube some time later depending on the tube length and the particle's velocity. If by this time the voltage on the next tube is of the correct polarity

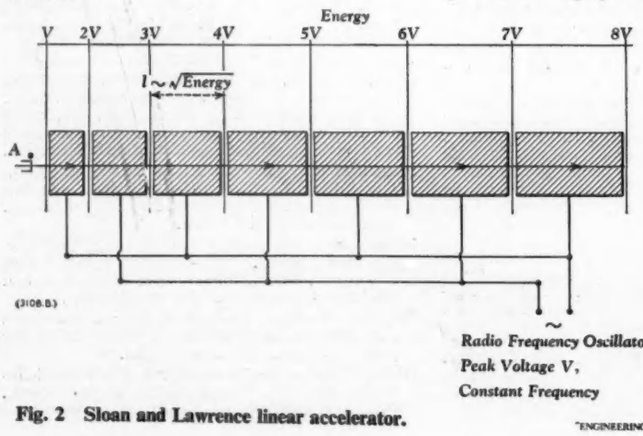
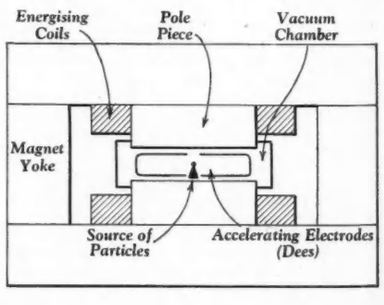


Fig. 2 Sloan and Lawrence linear accelerator.



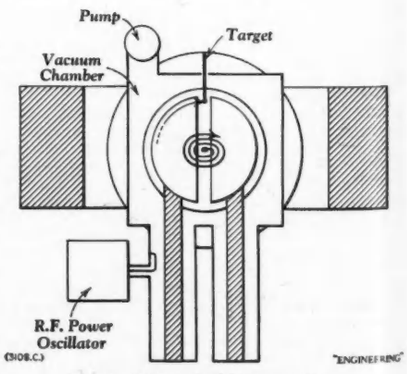


Fig. 3 Principle of the cyclotron.

* Director of the Proton Synchrotron Division, European Council for Nuclear Research, (CERN), Geneva.

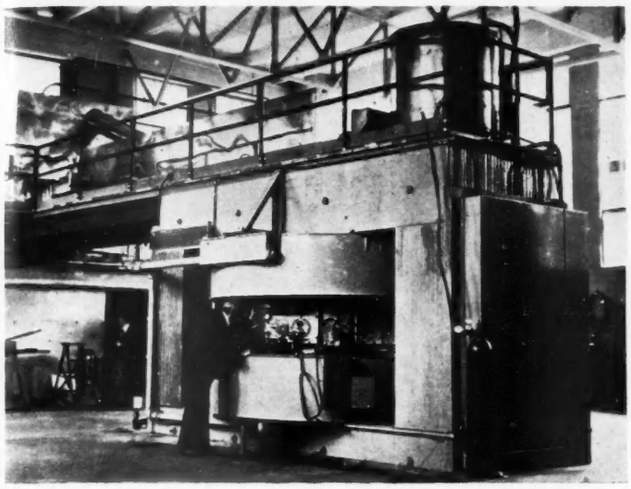
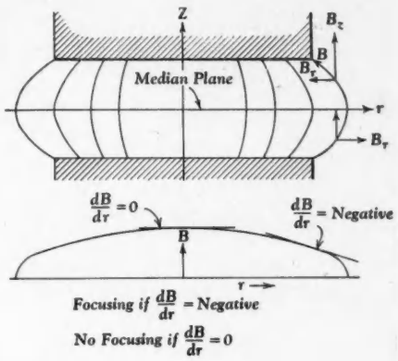


Fig. 4 60-in. cyclotron at Berkeley, California. This is one of the largest of this type of circular accelerator.



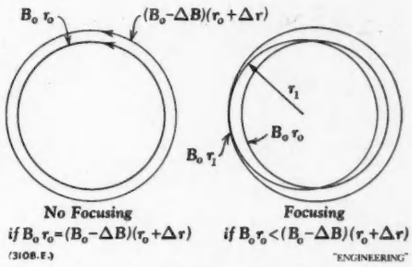


Fig. 5 Focusing of the particles in a circular accelerator.

with respect to the first tube the particle will be further accelerated. In other words, the periodic time of the high-frequency voltage source connected to the tubes must be the same as the transit time of the particle. It is easy to see that, if the voltage applied to the tubes is alternating with a constant frequency, then the drift-tube lengths increase linearly with the velocity of the particle or as the square root of the energy. From these ideas of multiple-step accelerations have been developed the whole family of linear accelerators for all types of charged particles. Although the limitations of such accelerators are not at first obvious in that voltage breakdown troubles can be avoided by using small enough steps, machines of this type to accelerate particles to very high energies become rather long. A recent design study for a proton accelerator showed that a machine to give 600 MeV particles would be about 300 yards long. Another limitation is in the high radio-frequency power needed to drive such an extensive system.

Soon after the operation of the first linear accelerator in 1930, Lawrence, at Berkeley, California, proposed to get over the length difficulties with the linear accelerator by bending the particles round in a circle by means of a magnetic field. Since the radius of curvature of particles in a magnetic field is proportional to the square root of their energy, then, if they are accelerated once per revolution, the machine operates just like a curled up linear accelerator where the tube lengths were also proportional to the square root of the energy. This new machine was called a cyclotron and there must be nearly a hundred such machines operating in the world today.

THE CYCLOTRON

Fig. 3 shows the necessary parts of a cyclotron. The particles start from some convenient source in the centre of the magnet gap at zero radius. There is one accelerating gap across the diameter of the magnet gap formed by two hollow electrodes, called Dees because of their shape. Thus a charged particle gets two accelerations per revolution and, as it gains energy, it spirals out from the centre of the machine keeping always between the poles of the magnet. The two Dees are joined to some convenient radio-frequency circuit, usually a pair of $\frac{\lambda}{4}$ resonant lines of which the Dees form capacitive loads at the open-circuit end. As in the linear accelerator, the radio-frequency is a fixed frequency and is supplied from a standard commercial transmitter in the frequency range 10-20 Mc. The whole of the space between the magnet poles containing the Dees in which the particles spiral has to be evacuated to a low pressure of 10^{-5} mm. Hg. to prevent the particles being lost by collision with air molecules. Fig. 4 shows the practical realisation of these ideas in one of the biggest of these machines.

It can be seen that there are two separate functions being carried out in a cyclotron. One is to provide an environment in which the particles can exist after generation in some source at the centre of the machine, and the other quite separate function is to accelerate the particles in that environment. It has been mentioned that there must be no gas atoms in the way of the accelerating particles, since by collision the particles would be knocked out of the machine before being completely accelerated. Even if there were no gas atoms at all, the particles would still wander out unless constrained by some focusing forces to the central plane between the pole pieces of

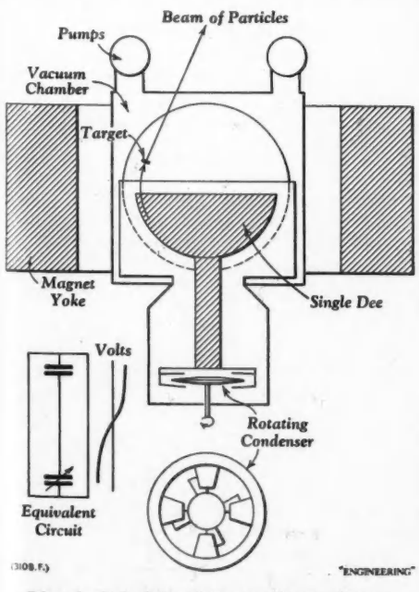


Fig. 6 Principle of the synchro-cyclotron.

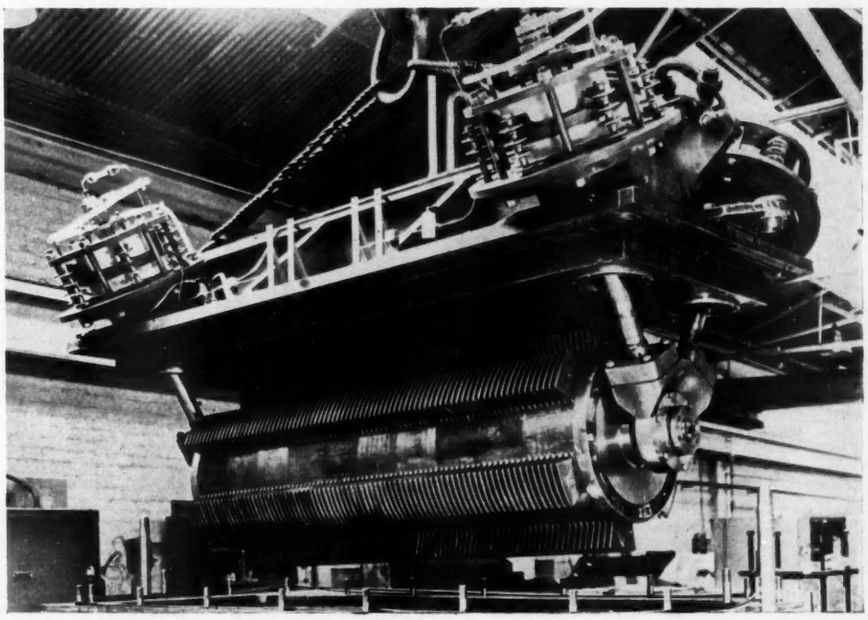


Fig. 7 Rotating condenser for frequency modulating the accelerating-voltage frequency in the Liverpool 156-in. synchro-cyclotron.

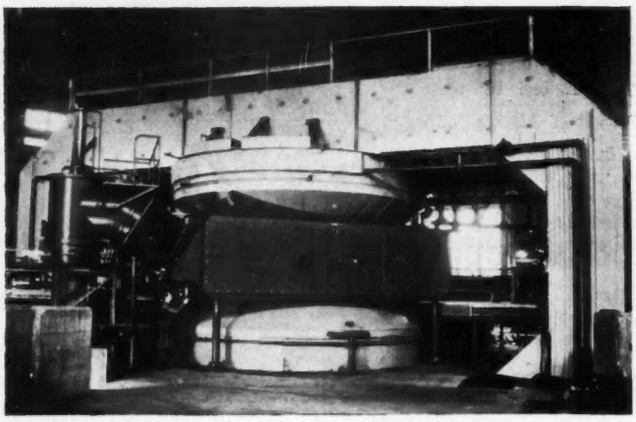


Fig. 8 Berkeley 184-in. synchro-cyclotron, showing vacuum chamber between the poles of the magnet and on the left the 30-in. diameter diffusion pump.

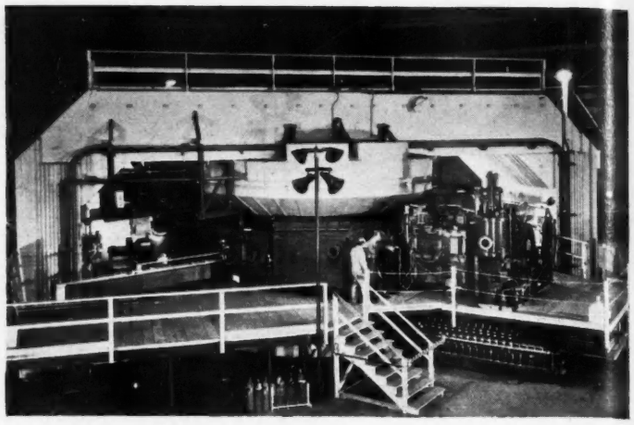


Fig. 9 Berkeley 184-in. synchro-cyclotron, showing high-frequency accelerating voltage system on the right.

the magnet. Fig. 5 illustrates how these focusing forces are derived from the main magnetic field which bends the particles round in circles. A fall off in the value of the magnetic field with radius gives the lines of field shown in the figure. By splitting up the curved field lines into axial and radial components, it can be seen that there is a radial component that is zero in the centre plane between the pole pieces and changes sign above and below this plane. If the lines of field bow outwards, the radial component of field always causes the particles to return to the median plane whether they are below or above it. Thus, during acceleration, the particles are confined to a region about the median plane of the magnet gap. There must also be some focusing in the radial direction. A particle will describe a circle in a magnetic field whose radius depends on the energy of the particle. For a given energy, the product of the magnetic field times the radius is a constant. Providing this product is increasing with radius, there is radial focusing. The limit is reached when the product is constant with radius when there are many circles with the same centre and different radii. Above this limit the particles spiral out of the machine, whether or not they are being accelerated, and are consequently lost. Therefore, although from the point of view of vertical stability the magnetic field should fall off rapidly with radius, it must not do so too rapidly, or the particles will become unstable radially.

There is a maximum energy to which particles can be accelerated in cyclotrons due to the effects of relativity. It has been stated that the frequency of the accelerating voltage applied to the Dees is constant. This enables the particles to be accelerated continuously providing that their rotation time is constant. As the particles gain energy, however, their velocity is not exactly proportioned to the square root of the energy. A particle of infinite energy cannot have a velocity in excess of the velocity of light. Thus, as the particles gain energy, they take a little longer to go round and so they begin to get out of phase with the accelerating voltage. Ultimately they reach zero phase and get no acceleration at all from the applied Dee volts. Increasing the Dee volts improves this state of affairs since the particles spend less time in the machine and so do not run out of phase so quickly. But finally electrical breakdown occurs between the Dees and this fixes the maximum energy realisable with cyclotrons. The largest of these machines has a pole tip diameter of 60 in. and can accelerate deuterons (heavy hydrogen nuclei) to 24 MeV and protons (hydrogen nuclei) to 15 MeV. This energy limitation has not stopped people from building a very large number of these machines but it did show that for higher energy machines a new idea was needed to get around the relativistic effects. In 1945, McMillan, at the Radiation Laboratory, Berkeley, California, and Veksler, in the U.S.S.R., simultaneously proposed a method for accelerating particles to very much higher energies than is possible in a cyclotron. The new machine is called the synchro-cyclotron.

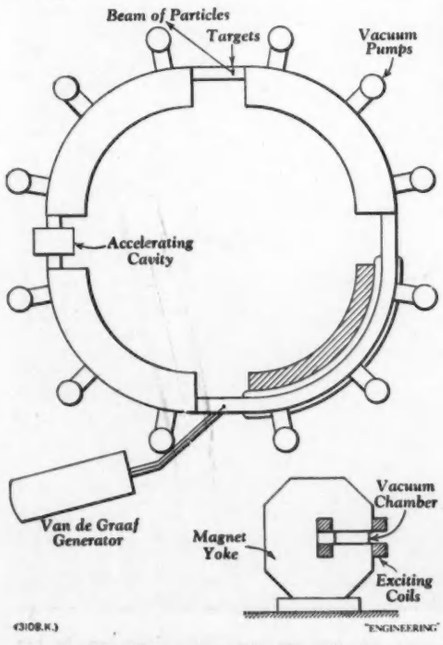


Fig. 10 Component parts of synchrotron.

THE SYNCHRO-CYCLOTRON

As a particle is accelerated in a cyclotron, its velocity is not quite as high as is predicted by non-relativistic mechanics. But, if we arrange that the frequency of the accelerating voltage falls as the particle gains energy, then at least we can accelerate a few particles up to any energy we like provided that we make the magnet big enough. Of course, having accelerated a few particles to high energy, the frequency of the accelerating voltage has to be returned again to its original value and then a few more particles can be accelerated from zero energy to maximum energy. The output from these machines therefore is not continuous as in a cyclotron but particles come out in bursts at the rate at which the accelerating voltage frequency is varied. The particular contribution of McMillan and Veksler was to show that firstly it does not matter how fast the accelerating voltage frequency is varied, so that the law of frequency against time is relatively unimportant and secondly that quite a lot of particles are accelerated each burst.

Particles emitted from the source when the applied frequency exactly matches the magnetic field get accelerated as in a cyclotron. Since the frequency is decreasing with time these particles continue to be accelerated despite the relativistic effects. The phase which these "reference particles" sit on the accelerating voltage waveform enables them to gain just the right amount of energy each revolution to suit the rate at which the accelerating voltage frequency is being varied. If the frequency is being varied very quickly the particles try to find a high voltage so that they can be quickly accelerated. If the peak applied voltage is not high enough to enable them to follow the frequency variation then they are lost. However it does not matter how slowly

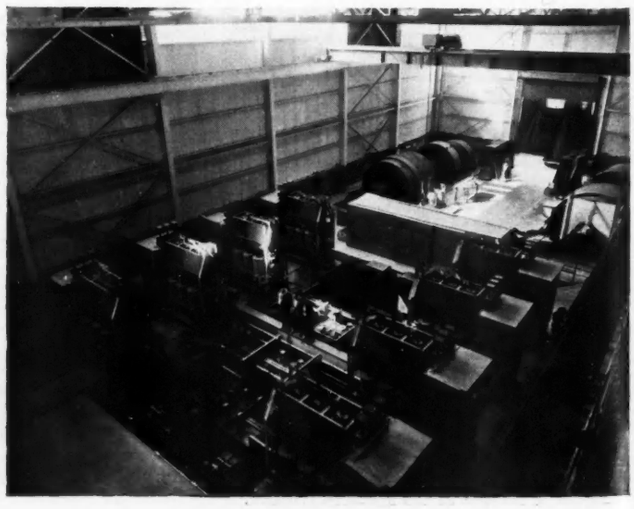


Fig. 11 Motor-generator plant, rectifier and inverter banks for Berkeley Bevatron.

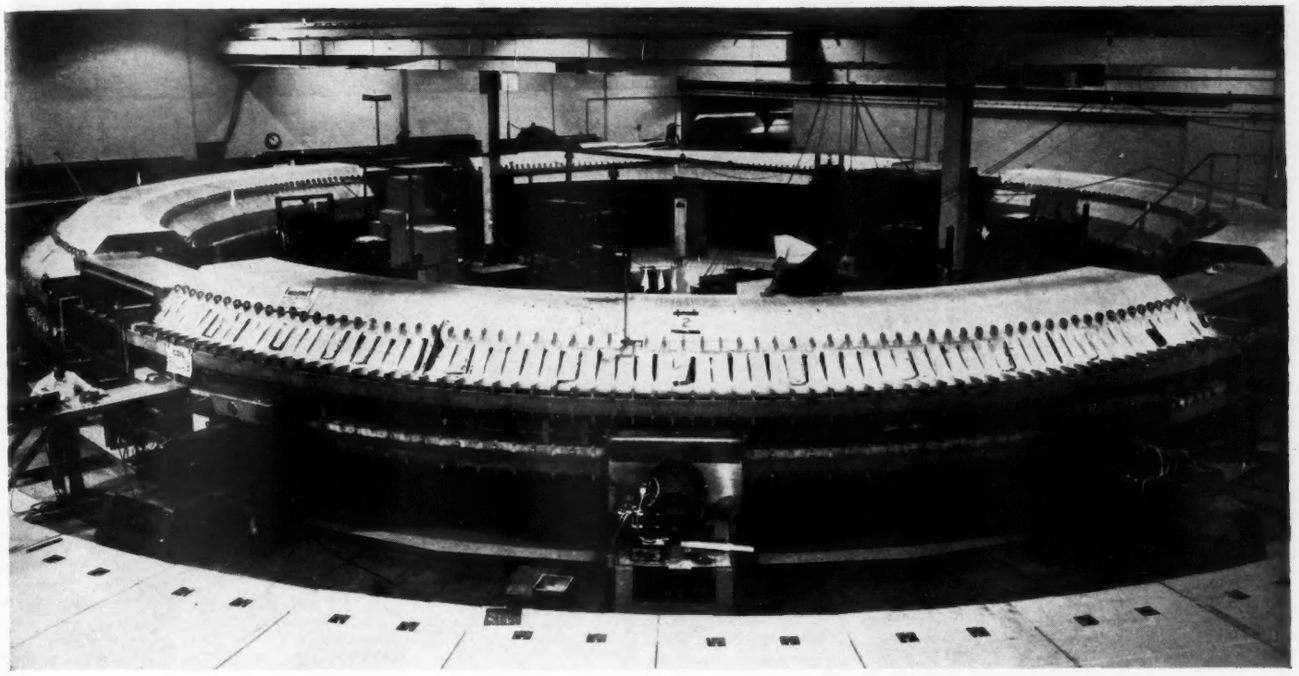


Fig. 12 Cosmotron at Brookhaven. The tank of the 4-MeV Van de Graaf set can be seen in the background.

the frequency is varied, since particles can always pick up less energy per revolution by adopting a phase nearly equal to zero. For similar reasons quite a number of particles are collected from the source at each sweep of the acclerating-voltage frequency. Those collected before the reference particles do not gain as much energy and so are caught up later on by the reference particles. Those collected after the reference particles gain more energy and catch them up. This idea is called phase stability.

In Fig. 6 are shown the component parts of a synchro-cyclotron. As can be seen, it looks very similar to an ordinary cyclotron, except that a device has been added to vary the frequency of the accelerating voltage with time. This device is usually a rotating condenser with many blades, or a vibrating condenser, like a very large tuning fork. To simplify the radio-frequency circuit only one Dee is used and built into a single resonant line structure. The rotating condenser can be introduced into the circuit in several ways depending on the frequency range required. The speed of rotation of the condenser is limited by normal mechanical considerations to a few thousand revolutions per minute and the particles come out in bursts at a rate of a few hundred bursts per second. Fig. 7 shows one such condenser which weighs several tons. Synchro-cyclotrons have been constructed up to 600 and 700 MeV for accelerating protons. Figs. 8 and 9 illustrate one of the largest machines of this type, built at Berkeley, California, in which the component parts can be seen in practical form.

These machines are quite large and correspondingly costly. For example, the synchro-cyclotron at Liverpool University, which came into operation at the beginning of this year, has the following engineering data.

Maximum energy of protons ..	400 MeV
Weight of steel in the magnet yokes	1,650 tons
Weight of aluminium in the magnet coils	65 tons
Power input to the magnet ..	840 kW
Magnetic field in the magnet gap	19,000 gauss
Total volume of vacuum system	1,000 cu. ft.
Pressure in vacuum system	5×10^{-6} mm. Hg
Accelerating voltage on the Dee	10 kV
Power input to the radio-frequency circuit	15 to 30 kW
Repetition rate of output pulses	200 per sec.
Total cost	£750,000

The machine gives a mean beam current of one microampere of protons at an energy of 400 MeV, which is an output in terms of power of 400 watts. Compared with the input power required to run such a machine of about 1 MW, the machine can hardly be called efficient. Nearly all the input energy goes into heat and very little into accelerating the particles. There are no theoretical reasons why such a machine should not be extrapolated to any energy. However, the cost of the machine increases rapidly with energy. The cost of a synchro-cyclotron to give 600 MeV protons is about £1·4 million. To double this energy would mean increasing the radius of the magnet poles by 1·5 and the weight of the magnet by about 3. The cost increase for the whole machine would be about four times the smaller machine, i.e., about £5·6 million. Such high cost figures make it desirable to look for alternative solutions to the synchro-cyclotron for very high energies. Clearly a large fraction of the cost is in the magnet and if this component could be reduced in volume, then further progress could be made towards higher energies.

THE SYNCHROTRON

At the time that McMillan and Veksler put forward their ideas on phase stability leading to the development of the synchro-cyclotron,

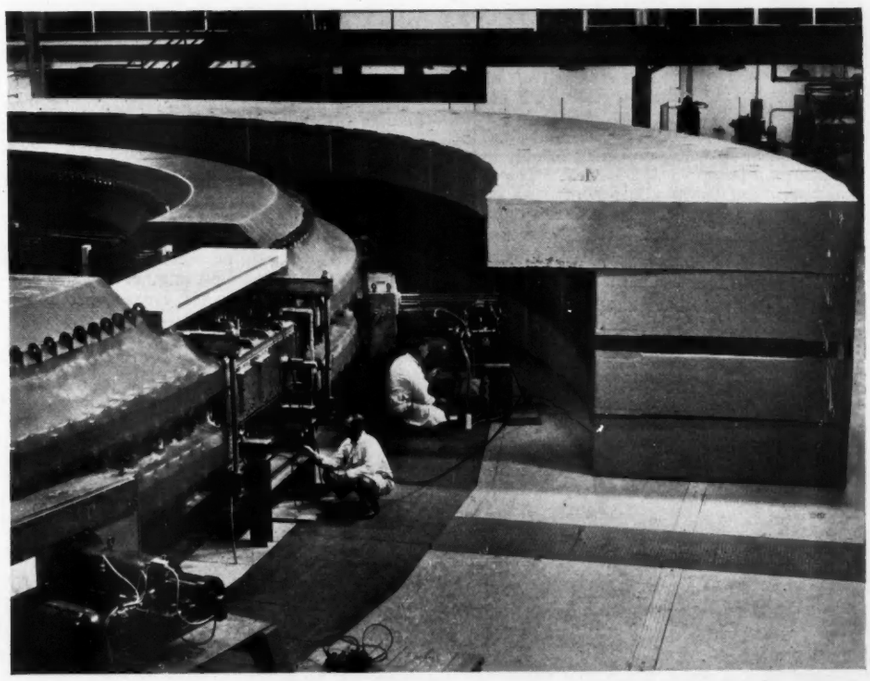


Fig. 13 Cosmotron at Brookhaven. View shows the magnet and one of the straight sections between the quadrants. The concrete structure on the right is part of the radiation shield.

another alternative machine was proposed in which instead of the magnetic field remaining constant during the acceleration of the particles it increased with time. Whereas in the synchro-cyclotron the radius of curvature of the particles increases with energy, in the synchrotron the radius of curvature remains constant and the magnetic field increases with energy or time. These are alternative ways of doing the same thing. In terms of economics, however, it is cheaper to make a large annular magnet than to make a large cyclotron type magnet and it is along these lines that the development of high-energy machines has proceeded.

If the magnetic field is increasing with time, then the frequency of the accelerating voltage is no longer even approximately constant with energy as it is in the synchro-cyclotron. In fact, in order to keep the particles at constant radius, the frequency of the accelerating voltage and the magnetic field have to follow a set relationship to within about one part in 10^3 which is a very close tolerance. The accelerating device is no longer a Dee and radio-frequency circuit but some form of accelerating cavity through which the beam of particles passes each revolution. Due to eddy-current effects in the iron of the magnet, the magnet yoke and pole pieces have to be laminated as in a transformer and even then it is impossible to start at zero magnetic field. So, instead of being able to start with a source of particles at nearly zero energy and zero magnetic field, we have to pre-accelerate them in some other machine and then inject them into the synchrotron when the magnetic field has reached the appropriate value after eddy-current effects have died away. This pre-accelerating is either made by a high-voltage set, such as a Van de Graaf machine, or by a linear accelerator. The component parts of a synchrotron for obtaining high-energy protons are shown in Fig. 10.

The magnet is fed by generators with a current that rises roughly linearly with time. It would be wasteful to throw away all the energy stored in the magnet when the peak field is reached, so the power source usually takes the form of a large flywheel coupled to an A.C. generator with a rectifier set that first supplies energy to the magnet and then becomes an inverter set taking the energy from the magnet and returning it to the flywheel. In the Cosmotron, which is one of the largest synchrotrons built (completed in 1952), the stored energy in the magnet is 12×10^6 joules. The peak power transfer is 26,000 kVA. The generator plant for such machines is quite large, as is shown in Fig. 11.

Figs. 12 to 15 are views of the two largest synchrotrons yet built, the Bevatron at the Radiation Laboratory, Berkeley, California, which accelerates protons to 6,000 MeV, and the Cosmotron at Brookhaven, Long Island, which accelerates protons to 3,000 MeV. The practical realisation of the component parts of the machine can be seen in the figures. To illustrate the engineering scale of these large machines, the following data are given for the Cosmotron.

Maximum energy of protons	~ 3,000 MeV
Radius of magnet	30 ft.
Weight of magnet yoke ..	1,650 tons
Weight of copper in coils ..	70 tons
Mean power input to magnet	600 kW
Maximum magnetic field ..	14,000 gauss
Total volume of vacuum system	300 cu. ft.
Pressure in vacuum system ..	5×10^{-6} mm. Hg
Accelerating voltage per revolution	2 kV
Power input to the radio-frequency circuit	20 to 50 kW
Repetition of output pulses ..	1 every 5 sec.
Total cost of machine and installations	About £2·5 million

This machine gives a mean beam current of 2×10^{-3} μamperes of protons at an energy of 3,000 MeV, which is an output of 6 watts. As in the synchro-cyclotron, the efficiency is microscopic. The cost per MeV of these large machines gives a good idea of the advantage of using a synchrotron for the higher energies. For the Cosmotron, it works out to about £800 per MeV; for a synchro-cyclotron it is about £2,000 per MeV.

In 1952, just after the successful running of the Cosmotron, two groups of people, one in the States, and one in Europe, started thinking about the next step in the development of high-energy accelerators. It can be seen from the above cost figures that building another synchrotron like the Cosmotron for ten times the energies would be far too expensive a project. A 30 GeV (1 GeV = 1,000 MeV) proton synchrotron would cost about £20 to £30 millions which is outside the budget of even State-financed organisations. The step that was taken to cut down magnet costs in the case of the synchrotron, by making a hollow annular magnet instead of a solid magnet extending from zero radius to the maximum radius, had to be carried another stage forward. As has happened so many times before in the history of high-energy machine development, the idea arrived just at the right moment. This time it came more or less simultaneously from Christophilis from Greece, and from Livingston, Courant and Snyder at the Brookhaven National Laboratory, Long Island. The machine developed from this idea is called an alternating gradient synchrotron and two large machines, one in the United States and one in Europe, are being designed and built at the present time for an energy of about 25 to 30 GeV. They should be operating around 1960.

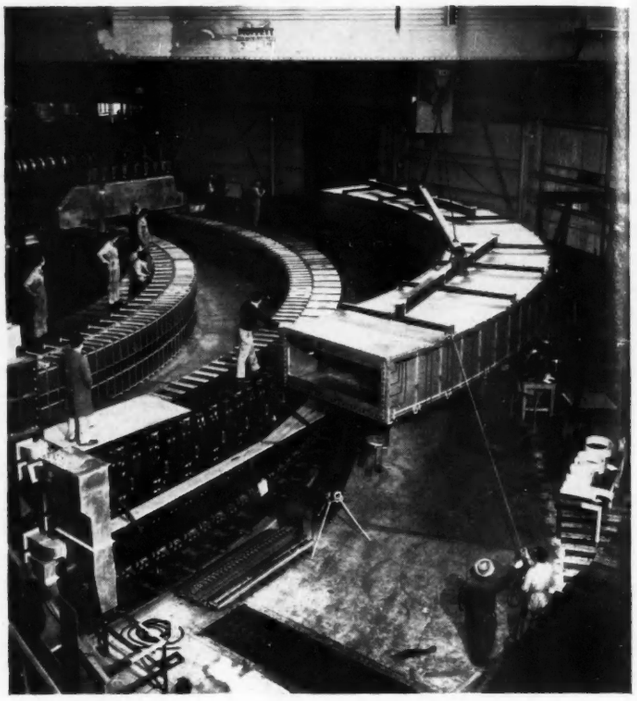


Fig. 15 Bevatron at Berkeley. One of the magnet quadrants during assembly. The top yoke of the magnet is not yet in place; the vacuum chamber tank is being moved into position.

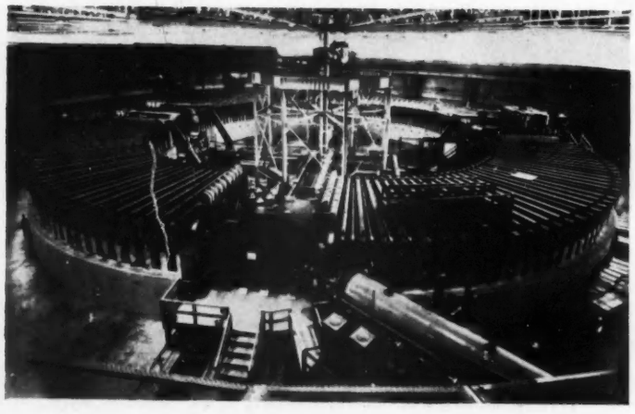


Fig. 14 Bevatron at Berkeley. In the foreground is the 10-MeV linear accelerator injector set.

ALTERNATING GRADIENT SYNCHROTRON

In the synchrotron, the dimensions of the magnet gap are determined by the amplitude of the oscillations of the particles being accelerated.

Equations of Motion $\ddot{\rho} = \omega_o^2 \, n\rho \quad \ddot{z} = \omega_o^2 \, nz$

Solutions for Radial Motion

Focusing Field, $n = -$

$$\rho = A \sin \omega_o n^{1/2} t + B \cos \omega_o n^{1/2} t$$

Defocusing Field, $n = +$

$$\rho = C \sinh \omega_o n^{1/2} t + D \cosh \omega_o n^{1/2} t$$

Particle Motion (Sector Length $= \frac{\pi}{2}$*)*

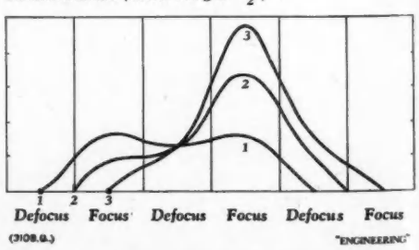


Fig. 16 Motion of particles in an alternating gradient synchrotron.

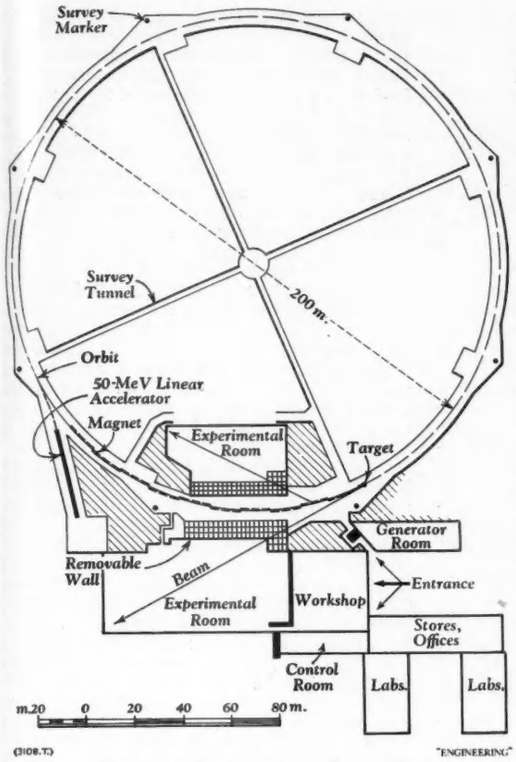


Fig. 17 Simplified plan of alternating-gradient proton synchrotron being constructed by CERN at Geneva.

The magnet gap fixes the magnet yoke size and so the cost of the magnet. The oscillations of the particles are of two kinds, the so-called free oscillations of the particles due to the focusing forces derived from the magnetic field, and the forced oscillations due to the particles oscillating in phase (and therefore in energy and radius) as a result of the "phase stability" phenomena. If these amplitudes could be reduced in some way, then the magnet cross section could be reduced and with it the cost of the machine. In the alternating gradient synchrotron the amplitude of the free oscillations is decreased by decreasing the wavelength of the oscillations and furthermore the amplitude of the radial-phase oscillations of the particles is smaller by a factor of about 50. These results are obtained by alternating the gradient of the magnetic field and by making the field gradient very much greater than is possible in a synchrotron. It has been explained that in a synchrotron if the rate of fall-off of magnetic field with radius is increased too much then the particles become unstable radially. This is unfortunate because increasing this gradient decreases the wavelength of the oscillations since it increases the focusing forces in the vertical direction. However by arranging that the gradient of the magnetic field is alternatively positive and negative in alternate sectors of the magnet very high gradients can be used and yet overall stability maintained. Fig. 16 shows the motion of a particle in such an alternating gradient magnet and demonstrates that stable oscillating motion is possible. It also shows the short wavelength of the oscillations since one cycle is complete in 8 magnet sectors and a typical magnet would have about 50 sectors round its periphery. The Cosmotron vacuum chamber which, of course, represents the limit of the permissible oscillation amplitudes, is about 6 in. high by 28 in. wide, whereas in the alternating gradient synchrotron we are designing for a chamber 3 in. high by 6 in. wide. In terms of magnet weight, the new machine, a simplified plan of which is shown in Fig. 17, uses 3,500 tons of steel against the Cosmotron's 1,650 tons, i.e., twice the steel for nearly 10 times the energy.

Just as in the Cosmotron, there has to be a pre-accelerator for the protons before they are injected into the synchrotron. Since the energy of this machine and its radius is higher than that of the Cosmotron by a factor of 10, the pre-accelerator also has to work at about 10 times the energy of the Cosmotron injector. This means that the pre-accelerator, which is a Linac giving 50 MeV protons, becomes in itself a major project.

Instead of using one accelerating cavity, about 20 are used, evenly spaced round the machine. There are also devices labelled quadrupole lenses, non-linear lenses, pick-up electrodes, which are distributed round the magnet ring. These correcting devices are needed to overcome the difficulties in constructing this new type of machine. The step from cyclotron to synchrotron introduced tight tolerances on the tracking of the frequency of the accelerating voltage with the magnetic field. The step from synchrotron to alternating-gradient synchrotron has introduced further tolerances of which the most important is the accuracy to which the magnet sectors have to be aligned to a perfect circle and in a perfect plane. The permissible misalignment is about ± 1 mm. and since the machine radius is 100 m. the tolerance asked for is ± 1 part in 100,000. Such a tolerance calls for very careful foundation design for the magnets and very precise survey techniques in setting the magnet sectors round the ring. Other close tolerances are on the field gradient, which has to remain constant throughout the accelerating cycle to within about 1 per cent. The various correcting lenses are put in to ensure that this tolerance is kept. If one bears in mind that during the acceleration cycle the protons travel a distance of 180,000 miles (which is about 8 times round the earth) in a tube 3 in. by 6 in., it is not surprising that some care has to be taken with the alignment of the machine and the focusing forces.

The alternating-gradient proton synchrotron of the European Council for Nuclear Research (CERN) is designed to have the following engineering features.

Maximum energy of protons	About 25 GeV
Weight of steel in magnet ..	About 3,200 tons
Weight of coils	About 110 tons
Mean power dissipated in magnet	1·5 MW
Maximum magnetic field ..	12,000 gauss
Total volume of vacuum system	220 cu. ft.
Pressure in the vacuum system	1×10^{-6} mm. Hg
Accelerating voltage per revolution	50 kV
Power input to R.F. circuit..	60 kW to 90 kW
Output pulses	1 every 4 to 5 seconds
Total cost	About £6 million

RADIATION HAZARDS

No mention has been made as yet about the radiation dangers with these machines. The output beams of most machines are lethal and even the stray radiation is extremely dangerous to human life. Furthermore, in order to carry out nuclear physics experiments, it is essential to reduce the general background radiation to a level often below the safe value for human beings. The synchro-cyclotrons are therefore surrounded by some yards of concrete shielding and often buried underground with a concrete roof several feet thick on top. Synchrotrons are usually surrounded by a concrete wall several yards thick with some concrete shielding on top. The new alternating-gradient synchrotrons will be built underground and the output beams will emerge through holes in a concrete wall

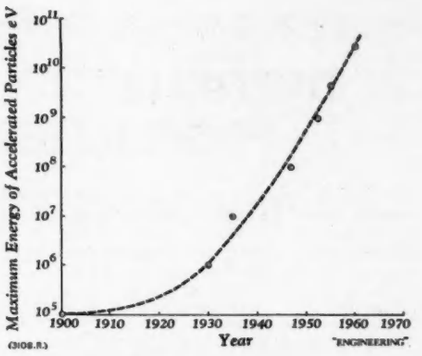


Fig. 18 Showing increase in maximum energy of accelerated particles since 1900.

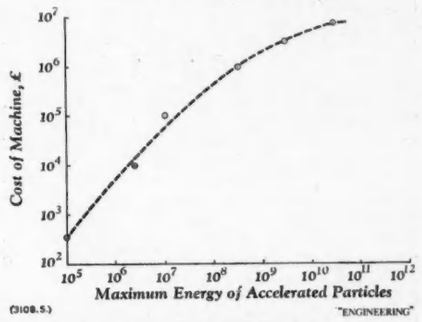


Fig. 19 Showing cost of accelerators in terms of maximum energy produced.

nearly 20 ft. thick and made from so-called heavy concrete which has a density of 3·5 as against 2·5 of ordinary concrete. Even with all this shielding great care has to be taken in the operation of these machines and elaborate systems of interlocking are necessary to prevent accidental irradiation of the staff.

CONCLUSION

Such a review would not be complete without some mention of possible future developments. Recent machines are of such a size that the construction projects take about six years to complete. Soon after a machine project gets under way, new ideas are being proposed for the next machine. A new type of machine has been suggested, even before the alternating gradient synchrotrons are half-way completed.

In Fig. 18 is plotted the way in which the energy of these machines has increased over the years. So far, there is no sign that the ingenuity of the machine designers is in any way failing. As can be seen from Fig. 1, there is a long way to go before the highest energies observed in the cosmic rays are reached. In fact, even if a machine is built encircling the earth, using the same magnetic fields at present used in machines, the maximum energy will not reach the cosmic rays energies. However, there are many decades to go in energy before such an extreme machine need be contemplated. Fig. 19 how the advance in energy is being gained for ever smaller increases in cost.

In general, one can conclude that the ingenuity of the designers will find a method of increasing the energy of machines above the present 30 GeV projects at a cost not very much greater than at present committed for the 30 GeV machines. This can only be done at the expense of closer tolerances on all parts of the machine and therefore depends on technological developments.

Acknowledgements.—The Author wishes to thank the following Research Centres for permission to use photographs and data of their machines: Brookhaven National Laboratory, Brookhaven, Long Island, U.S.A.; Radiation Laboratory, University of California, Berkeley, Cal., U.S.A.; Physics Department, Liverpool University, Liverpool.

Institute of Metals Autumn Meeting (*concluded from page* 488)

DEFORMATION AND WORKING PROPERTIES OF METALS

Concluding our report of the 47th annual autumn meeting of the Institute of Metals, held in Buxton from Monday, September 19 to Friday, September 23, we now deal with the last four papers presented and discussed in session "B" on the afternoon of the first day of the meeting.

DEFORMATION AND CREEP OF ALUMINIUM ALLOYS

The papers were all upon the theme of "Deformation and Creep of Aluminium Alloys," and were presented by Dr. N. P. Allen, as *rapporteur*. The first, on "Some Metallographic Observations of the Creep of Aluminium-Copper Alloys," dealt with work done by Dr. A. H. Sully and Dr. H. K. Hardy, at the Fulmer Research Institute, Stoke Poges. The authors stated that their work on high-purity and normal-purity aluminium-copper alloys containing 3 and 4 per cent. of copper provided an interesting example of the interaction of deformation during creep and the precipitation process. Ageing before and during the early stages of the creep test led to relatively-narrow regions, depleted in solute, on either side of the grain boundaries. Creep occurred preferentially in those regions of low resistance to deformation, the presence of which controlled the creep behaviour of the high- and normal-purity alloys aged at 190 deg. C.

Plastic flow accentuated the precipitation process in the material immediately adjacent to the grain boundary, thus widening the band of material having a low resistance to deformation.

Shear displacement across boundaries favourably oriented to the applied stress was accompanied by the formation of fissures transverse to the stress direction. High-purity alloys showed the effects most prominently and gave intercrystalline fractures. Normal-purity alloys possessed a much better creep resistance. The results pointed to the importance of grain-boundary stability in creep-resistant alloys.

The second paper, by Dr. D. McLean and Mr. M. H. Farmer, was a communication from the National Physical Laboratory and dealt with "Grain-Boundary Movement, Slip, and Fragmentation during Creep of Aluminium-Copper, Aluminium-Magnesium, and Aluminium-Zinc Alloys." The authors stated that polycrystalline specimens of Al-Cu, Al-Mg and Al-Zn alloys had been tested in creep, and observations had been made of the movements, at grain boundaries, of slip and of the fragmentation of the original crystals into sub-crystals. It had been concluded that slip and grain-boundary displacement took place concurrently and bore a constant ratio to one another during a given test. The magnitude of this ratio depended upon the conditions of the test.

The third paper was by Dr. G. R. Wilms of the Defence Standards Laboratories, Melbourne, Australia. Its title was "Some Observations on the Creep of Pre-Strained Aluminium." The author stated that X-ray and metallographic observations had been made during the creep of specimens of high-purity aluminium after preliminary deformations. The experiments had been carried out under constant tensile loads at different temperatures, and the results compared with those obtained on annealed material strained under the same conditions of load and temperature.

It had been found that the initial sub-structure grew within the grains until it became comparable in size with the equilibrium structure produced during the secondary creep of the corresponding annealed specimen. The equilibrium structure appeared to be attained by a two-stage process. The creep rate remained approximately constant during the first stage, while during the second stage the creep rate increased and continued to increase until it became comparable with that of the corresponding annealed specimen.

The fourth paper, on "Plastic Deformation of Aluminium-3·5 per cent. Copper Alloy Single Crystals," was by Mr. K. M. Carlsen and Professor R. W. K. Honeycombe, and dealt with work carried out in the Department of Metallurgy of the University of Sheffield. The authors stated that long crystals of an aluminium-3·5 per cent. copper alloy, prepared by the strain-anneal method, had enabled a comparison to be made of specimens of identical orientation after different heat treatments. Crystals of the air-cooled solid solution resembled pure metals, in so far as plastic deformation occurred on well-defined slip planes. In contrast, the fully-hardened crystals did not show visible slip. The behaviour of over-aged crystals fell between these two extremes.

DISCUSSION

In the course of the brief discussion which followed the presentation of these four papers, Dr. J. P. Dennison confirmed that work on other alloys had shown that denuded zones at the grain boundaries such as those described by Dr. Sully and Dr. Hardy gave rise to a corresponding decline in creep resistance properties. Referring to this point in a brief reply, Dr. Sully emphasised that, in normal-purity alloys, the depleted layers adjacent to the boundaries were a significant feature of the microstructure as they were also in alloys of high purity, but they were narrower in the former than in the latter.

In the evening a Civic reception was held at the Palace Hotel by invitation of the Mayor and Corporation of Buxton.

THE WORKING PROPERTIES OF METALS

On the morning of Thursday, September 22, after the presentation of the Platinum Medal, to Dr. C. J. Smithells M.C., as described on page 475 of our issue of September 30, two simultaneous technical sessions were again held. The first (Session "A") was on the theme of the "Working Properties of Metals." The chair at this session was occupied by Dr. L. B. Pfeil, O.B.E., F.R.S., and Mr. G. L. Bailey, C.B.E., acted as *rapporteur* of the three papers on the agenda.

The first dealt with "The Effect of Strain Rate and Temperature on the Resistance of Aluminium, Copper and Steel to Compression"; it was a report of the Solid Mechanics Group of the British Iron and Steel Research Association, by Dr. J. F. Alder and Dr. V. A. Phillips, both of whom were formerly at the Cavendish Laboratory of the University of Cambridge. The authors stated that stress/strain curves had been determined, during compression to 50 per cent. reduction of height at constant true strain rates in the range 1 to 40 sec.$^{-1}$ for (1) commercial-purity aluminium from −190 deg. to 550 deg. C., (2) phosphorus-deoxidised copper from 18 deg. to 900 deg. C., and (3) a 0·17 per cent. carbon steel from 930 deg. to 1,200 deg. C. Glasses had been used as lubricants at the higher temperatures. The stress-strain curves for copper at 750 deg. and 900 deg. C., and for steel showed a drop in stress at higher strains, unlike those for aluminium at 350 deg. to 550 deg. C., which continued at approximately constant stress above a certain strain. The stress for a given strain increased with strain rate in fair agreement with a power law.

The second paper was a communication from the British Non-Ferrous Metals Research Association by Mr. E. A. Leech, Mr. P. Gregory and Mr. R. Eborall. It was concerned with "A Hot Impact Tensile Test and its Relation to Hot-Working Properties." The authors stated that a simple attachment to a standard Izod impact machine permitted tensile test-pieces to be broken at strain rates of about 250 sec.$^{-1}$. By mounting the furnace employed to heat the specimens only a few inches from the anvil, the operation of removing the specimens from the furnace and placing them in the apparatus took 2 seconds only, and sometimes less. After fracture, the end of the specimen held in a movable jaw was thrown off the anvil and could be caught conveniently in a quenching tank if desired.

In order to assess the sensitivity of the test, some bismuth coppers were used and these showed that the test had the obvious advantage that it gave two direct measures (elongation and reduction in area at fracture) of the capacity of a material for hot deformation, whereas the notched-bar value was a function of both the amount of deformation before fracture and the force required to effect the deformation.

Chill-cast brasses, bronzes and aluminium bronzes, of which the hot-working characteristics were well known, were tested at temperatures from room temperature to from 850 deg. to 900 deg. C. In each of three brasses containing the β phase, the ductility fell slowly with temperature up to 500 to 600 deg. C., and then rose steeply as the proportion of β increased, reaching a very high value for the 62 : 38 alloy at 850 deg. C. The 80 : 20 α-phase brass, on the other hand, had a sustained, moderately-high ductility throughout the temperature range.

The aluminium bronzes behaved much as expected. The ductility of the α-phase alloys was high at the lowest temperatures (the specimens being unbroken at room temperature and 150 deg. C.) and fell somewhat as the temperature was raised, with a pronounced minimum at about 500 deg. C.

The results showed that, in alloys specially suitable for hot working, the test reflected the marked increase in ductility as the alloys passed into the hot-working range.

A comparison had also been made between the ductility shown by a bronze in the test and its liability to edge cracking in hot rolling at various temperatures.

The third paper dealt with "Inhomogeneous Deformation in Rolling and Wire-Drawing" and was by Dr. B. B. Hundy and Dr. A. R. E. Singer. It described work carried out in the Department of Industrial Metallurgy of the University of Birmingham. The authors stated that microhardness measurements made on copper, 70 : 30 brass, aluminium, and mild steel indicated that there was an analogy between the inhomogeneity of deformation in rolled strip and that in drawn wire. Copper, brass and aluminium all showed surface-hardening when lightly rolled or drawn. The inhomogeneity was dependent on the working conditions, and disappeared after moderate reductions by rolling or drawing. The surface-hardening was caused by frictional forces acting between the rolls or die and the metal, and increased as the coefficient of friction increased. In general, a specific surface hardness could be associated with definite frictional conditions.

Rolling and drawing also gave rise to a secondary zone of hardening situated between the core and the surface of the metal. This could be observed in both copper and steel, and it did not decrease in magnitude as the reduction was increased. It was believed that secondary hardening was associated with the manner of deformation during rolling and drawing, and was largely independent of friction.

DISCUSSION

Dr. J. C. Chaston, who opened the discussion, said that the three papers before the meeting were to be welcomed in that they constituted a new approach to rolling problems. For too long there had been discussions on power requirements. In the non-ferrous metals industry, a matter of great concern was the arrest and control of edge and other forms of cracking of the material. One of the papers had dealt

with the compression deformation of metals. He (Dr. Chaston) was always suspicious of compression tests because it was possible to have perfect compression only when the lubrication was entirely adequate. In practice there was always a certain degree of friction at work, hence it was difficult to have entirely reliable results. It was to be noted, moreover, that the paper by Dr. Alder and Dr. Phillips was highly theoretical. The paper by Mr. Leech, Mr. Gregory and Mr. Eborall constituted a determined effort to establish a laboratory method of measuring the working characteristics of metals and it implied that an impact tensile test provided a ready means of accomplishing this. It was difficult to see, however, how a connection could be established between the behaviour of a metal in rolling and values obtained in an impact tensile test.

In answer to this Mr. R. Eborall agreed that the working characteristics of metals presented extremely complicated problems. Tensile stresses, however, did develop during the rolling of metals and gave rise to cracking. It was therefore appropriate to use an impact tensile test in the determination of the working characteristics of metals. Moreover, the new technique had been applied in connection with the rolling of titanium alloys, which had been found difficult to work, and the results had been found helpful.

Professor H. O'Neill said that Mr. Eborall had defended the new test well and, in their paper, he and his colleagues had shown that the test worked satisfactorily. If now other investigators would take it up, data would be accumulated on the subject and this would be all to the good. One of the advantages of the tensile test was that it did give one answer. He himself had done work on somewhat similar lines, but using Mallock-cone and truncated-cone compression tests, and he hoped to publish this at some future date.

Mr. J. G. Wistreich said that one of the authors had remarked that some of their data had been given in tabular form and others in graph form at the request of the publication committee of the Institute. In such cases several copies of those graphs which had not been published might be deposited with the Institute for loaning to other investigators. This would be especially useful if the graphs contained data capable of being tried out and used in subsequent experiments.

Dr. D. E. R. Hughes thought that a test for ascertaining the hot-working properties of a metal should furnish the best temperature at which to carry out the hot working of that particular metal. They, at the G.K.N. Group research laboratory, at Wolverhampton, had found a torsion test (in which the metal specimen was twisted) useful in that connection. By plotting the number of revolutions against the temperature of the test it had been possible to determine the correct temperature at which the rotary piercing of a billet for tube making should be carried out. Mr. J. V. Lyons, who also spoke on this subject, gave some typical results for torsion and impact-tensile tests on commercial-purity aluminium and aluminium alloys. A third speaker on tube making, Mr. F. A. Hodierne, said that by means of the tests mentioned it was possible to take a completely unknown alloy and ascertain its optimum rotary-piercing temperature and also, to a certain extent, the power required for the operation.

RADIATION DAMAGE TO METALS

The proceedings at session "B" on Thursday morning, September 22, took the form of a discussion on "Radiation Damage to Metals and Associated Problems," arranged by the Metal Physics Committee of the Institute. The chair was occupied by Professor R. W. K. Honeycombe and the discussion, which was of an informal character, was preceded by five short introductory addresses delivered by members of the staff of the metallurgical division of the Atomic Energy Research Establishment.

At the conclusion of Sessions "A" and "B" a short plenary meeting was held presided over by Dr. Maurice Cook, at which votes of thanks to the chairman and members of the Sheffield local section, Professor A. G. Quarrell and members of the reception and executive committees, the companies and individuals who had contributed to the hospitality fund for the meeting and had opened their works and establishments to the visiting members and to all others who had contributed to the success of the meeting, were passed with acclamation.

In the afternoon visits were paid to several works and in the evening a banquet was held at the Palace Hotel, by invitation of the reception committee, and the whole of Friday, September 23 was devoted to a coach tour of Derbyshire.

THE PRODUCTION AND DISTRIBUTION OF ELECTRICITY

TENTH CONGRESS OF UNIPEDE

Concluded from page 447

Unipede—the Union International des Producteurs et Distributeurs d'Energie Electrique—meets every three years in a capital city. This year's conference in London was held from September 19 *to* 27. *In this article we summarise some more points from the* 41 *papers that were presented.*

PROBLEMS OF STARTING UP

The last of the reports of the thermal generation Study committee was by Mr. J. Ricard of Electricité de France, and dealt with the advantages and problems of shutting down and starting up turbo-alternator sets and boilers. The ability to shut down sets overnight and for week-ends when the load is light appears to offer economic advantages in fuel saving. This, however, is doubtful in the case of overnight stoppages, as the increased consumption during the restart may more than equal the total consumption when running at the "technical minimum" load all night. The saving during a week-end is more definite. Decreasing the time taken during a restart makes some improvement in the saving but adds to the risks, and the author tends to the conclusion that the savings involved are not worth the increased risk of damage to the plant. Nightly and week-end shut-downs are, however, common practice in many countries. In fact the Consolidated Edison Company of New York has for many years shut down sets operating at 1,250 lb. per square inch and 900/950 deg. F., bringing them up to speed again in 20 minutes.

As regards possible causes of trouble during starting, the main risk on the turbine is that of excessive temperature differences causing uneven expansion as between rotor and case, and deformation of the case. With alternators, frequent starts and stops cause fatigue of the insulation due to the expansion and contraction of the copper, the progressive result being an inwards movement of the end windings. In boilers, temperature stresses and overheating are again the chief risks, the latter applying in particular to the superheaters. In these, also, any condensation must be cleared.

Where it is known that there will be frequent stopping and starting, various arrangements can be made to improve reliability. High-temperature turbines may have double shells, expandable nozzle-chests, symmetrical shapes and rotors forged in one piece; alternators should have creep-resistant insulating materials, and elastic conductors; boilers should have drainable superheaters and special arrangements incorporated where re-heat cycles are used. In addition there should be adequate measuring equipment on all units so that the starting up process can be accurately controlled, and there should be starting instructions agreed by both manufacturer and user which must be rigidly followed.

A particular condition where the ability to start up quickly was needed was instanced in one of the papers presented by the hydro-electric generation study committee. It was presented by Mr. G. Bardon, of Electricité de France, and was entitled "The Nature and Method of Operation of Steam Power Stations Used for Equalising Water Power." The main point was that as the suitable sources of water power are becoming used to the full, other means are having to be found to provide peak load assistance. The report applies in particular to Austria, Bavaria, France, Italy and Sweden, there being detailed descriptions of the operation in each of these countries. In general the requirements given for these auxiliary steam stations (which may use natural gas, coal or oil as fuel and which operate only for about 3,000 hours a year) are similar to those listed by Mr. Ricard, but local conditions tend to govern details.

Another paper in the same series, presented by Dipl.-Ing. W. Pietzsch of Bayerische Wasserkraftwerke A.G., München, dealt with the exploitation of water sources such as rivers, using small reservoirs to even the over-all flow. A particular example is the River Lech, which, when completed, will have 26 stages of generation between Fossen and Augsburg. Two reservoirs are used, both small; the upper one stores water during the night when the load is small and releases it during the day as the load rises, while the one at the last stage reverses this process, storing water during peak periods and releasing it later so that the final flow of the river is kept even throughout the day and night. For other river users, particularly for navigation, this is an important matter.

INTERCONNECTIONS

The problems of frequency and power transfer regulation between interconnected systems formed the subject of a paper presented by the international interconnections study committee and given by Mr. F. Cahen, of Electricité de France. These are important technical problems which must be faced if there is to be any large degree of interconnection between systems in Western Europe. At present, all degrees of interconnection are in use, from that of the local stations to the links between France, Germany, Belgium, Saar, Switzerland, Italy and Spain and the proposed cross-Channel link between Great Britain and France. In general, power transfer is regulated by an agreed system operating at certain times, but frequency must be continuously regulated to avoid excessive surges. Frequency-control systems differ in different systems, but it appears fairly certain that automatic control is necessary when links are of an international order. In Great Britain at present, manual control is used from eight area centres, but it is intended to install automatic control equipment to give a combined system which will correct errors in the manual control. If the cross-Channel cable is laid, fully automatic control will be needed by about 1959. In any event, it may be economically justified by 1965.

The pre-determination of power fluctuation was the object of a series of tests carried out between the C.E.A. and E.D.F. with particular regard to the cross-Channel link. Rapid fluctuations have little effect on the heating of the cable except to raise the general level very slightly, but long-term changes raise the level considerably. From the tests, the linkage of two large systems by a single 132 kV cable of 200 MVA nominal capacity appears to be quite practicable, but very close regulation of the frequency is essential.

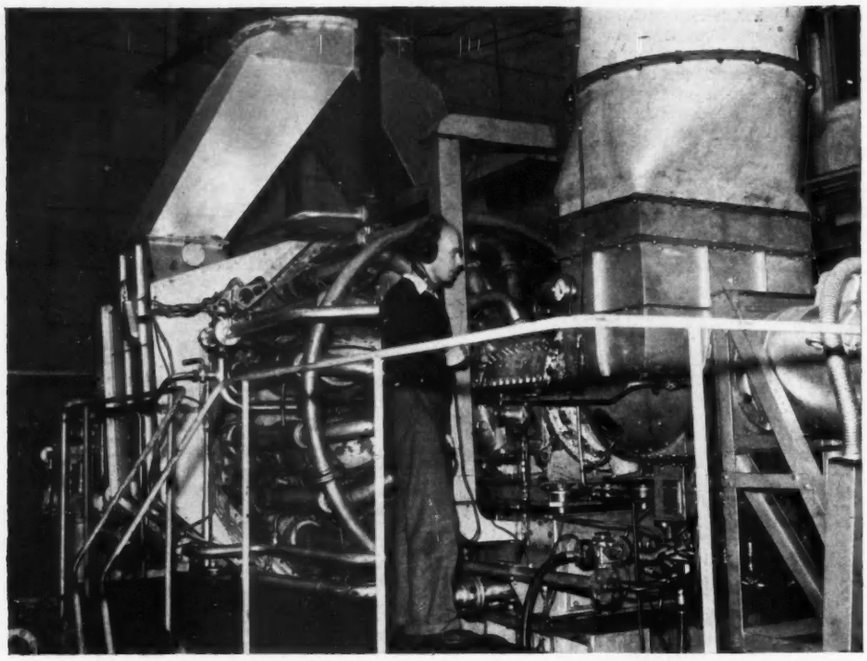


Fig. 6 The 1,000-kW Allen prototype gas turbo-generator set for major warships now undergoing endurance tests has run nearly 4,000 hours.

NATIONAL GAS TURBINE ESTABLISHMENT

(2) WORK IN PROGRESS

The primary purpose of the National Gas Turbine Establishment, the headquarters of which are at Pyestock, Hampshire, is to foresee and solve the problems that are likely to beset turbine manufacturers, and to suggest the most fruitful lines for future development. The Establishment also acts as an information exchange centre between the various firms and it is believed that the " pooling " of technical knowledge is one of the reasons why the British aircraft gas-turbine industry retains its leading position.

Although most of the effort at Pyestock is, perhaps, directed to the advanced problems of the aircraft gas turbine, work is also in progress on industrial and marine applications. In the Admiralty test house, two auxiliary gas turbines for generation of ships' electricity are now undergoing trials—the 1,000-kW prototype set for major warships constructed by W. H. Allen, Sons and Co., Ltd., Bedford, which has now run nearly 4,000 hours (Fig. 6); and a standard 750-kW Ruston and Hornsby turbo-alternator modified slightly for running on residual fuels. This latter installation, successfully run on gas oil, is now to be run on a residual fuel to assess the effects of corrosion and deposition.

RESIDUAL OIL BURNING

Also directed to the development of residual oil burning in industrial turbines is research on the suppression of inorganic ash formation.

Combustion of fuel oil droplets proceeds via distillation of the volatile constituents, leaving particulate carbon residues, containing the ash. With conventional tubular-type chambers, combustion of these carbon particles is substantially complete, and free ash is formed. The melting range of the ash is commonly 600 to 700 deg. C. and some of the constituents are volatile (e.g., vanadium pentoxide). During the passage of the exhaust gas through the turbine, ash may adhere to the turbine blades. At turbine temperatures between 500 and 600 deg. C., solid build-up of ash deposits occurs, interfering with the aerodynamics of the turbine. At higher temperatures the molten ash fluxes away the protective chromic oxide layer on the turbine blade material (e.g., Nimonic alloys) and oxidation of the metal ensues, leading in time to the impairing of the mechanical properties of the alloy.

Means of overcoming these two sources of trouble lie in preventing the arrival of the ash particles at the turbine blade surface. This can conveniently be done by arresting the combustion process at a point at which there is still a quantity of carbon associated with the ash, thus giving a dry particle which cannot adhere to the turbine. Effective control of ash deposition has been demonstrated on a test rig for some conditions, and the penalty in terms of loss of efficiency as unburnt carbon need only be of the order of 1 per cent.

In the vortex type of chamber under development, the atomised fuel spray is ignited in a precombustion chamber where the volatile components of the fuel are burnt. The products then enter the vortex chamber where the carbon particles burn steadily as they proceed in a spiral path towards the centre of the vortex.

Ideally, the radial position of a particle in the vortex is controlled by the centrifugal forces on the particle and the inward drag caused by the flow of gases. Thus, as the particle burns, its weight is reduced and it passes towards the vortex centre. If particles of a uniform size can be supplied to the system, and if the flow of air is uniform, the particles can be exhausted at a uniform state of burn-out and this can be controlled by the rate of air flow and the temperature attained in the cyclone. These requirements have not yet been fully met but experimental work to achieve this object is proceeding.

The chamber design has been arranged to provide a very wide range of burning temperature and distribution of the air supply, so that the carbon-to-ash weight ratio in the exhaust can be varied at will. After preliminary calibration on the test rig, this chamber will be run on the 750-kW Ruston and Hornsby gas turbine which is being tested by the Admiralty. In order to make it possible to adjust the internal form of the vortex chamber, a monolithic ceramic construction has been used. This also provides adequate cooling while using vortex outlet temperatures of the order of 1,400 deg. C.

COAL-BURNING GAS TURBINE

Ash deposits on the turbine blading form also one of the principal obstacles to the development of economical coal and peat-burning gas turbines for industry. To investigate this and other problems, the Ministry of Fuel and Power operates an ash-forming fuels laboratory within the National Gas Turbine Establishment.

The deposition of ash on blades may depend on the chemical composition and degree of pulverisation of the coal; the temperature and rapidity of combustion; the efficiency of the fly-ash separator; the size and concentration of the dust passing through the turbine; the gas pressure, temperature and speed; the blade form and temperature. In order to separate the effects of these factors a flexible rig is being developed in which the variables may be altered one at a time. In this way a general picture of the mechanism of fouling will be built up.

The ash fouling rig at present consists of a small coal-burning chamber, a long-cone cyclone separator and a cascade of fixed blades to represent the turbine. An interesting feature is the fluidised coal feed to the combustion chamber through a feed-pipe of $\frac{3}{16}$ in. internal diameter. Initially the effect of coal composition and sizing will be investigated on this rig.

Tests of a similar nature in which chemically inert dusts are being introduced into a hot gas stream before being passed over a cascade of blades are also being carried out to show up the physical rather than the chemical aspects of blade fouling.

AIR-COOLED TURBINE BLADES

Although the approach to the high-temperature gas turbine has been dictated primarily by military aircraft needs, N.G.T.E.'s successful work on air-cooled turbine blades and other components is likely to play an important part in the industrial turbine field (Fig. 8).

The major problem that in the past has impeded the development towards higher temperatures is that of cooling the very hot and highly-stressed turbine blades. Since the end of the war the National Gas Turbine Establishment has carried out much pioneer development work in this field which has culminated in the building and running of an experimental air-cooled turbine which has operated successfully at gas temperatures of well over 1,000 deg. C.

The development of blades with internal cooling surfaces and passages raises problems of manufacture. Among the methods that have been developed are the use of metal powders, using cadmium wires to locate the cooling air passages; when compacted in the furnace, the cadmium wires melt leaving free air ducts. The lost-wax process has also been employed for blade fabrication using silica tubes to locate the air ducts, these being subsequently dissolved by caustic soda. Extrusion and rolling methods have also been developed.

In parallel with the development of cooled blades a continuous effort is being made by sections of industry to develop new materials for turbine blades which might be capable of operating at much higher gas temperatures than at present without the necessity for cooling. There being relatively little scope left for spectacular development of heat-resistant metallic alloys, attention has turned in recent years to ceramic and cermet materials. So far, however, the inherent brittleness of such materials, which leads to rapid failure due to mechanical shock, and often by thermal shock, has proved to be a major barrier to their use for blading. Nevertheless, work in this field continues under the sponsorship of the Ministry of Supply and, in the marine engine field, under Pametrada.

A further problem arising in the high-temperature engine is that of cooling the hot surfaces in the combustion chamber and the turbine

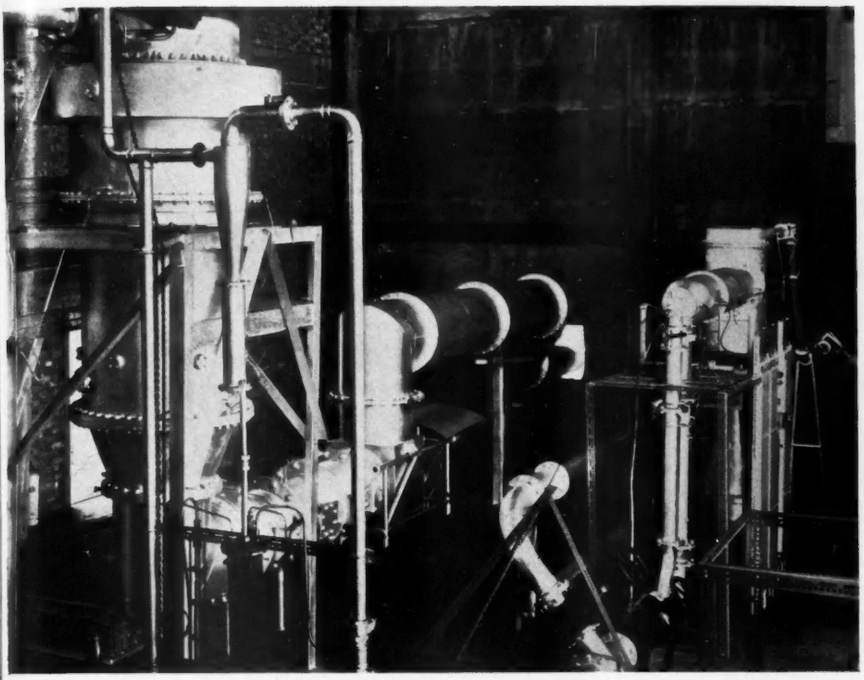


Fig. 7 The ash-fouling rig comprises a small coal-burning chamber, a long-cone cyclone separator and a cascade of fixed blades to represent the turbine.

exhaust or jet pipe. For lightness, compactness, and general reliability some form of direct air cooling appears to be the answer. The most effective method found is that of "effusion" cooling, in which cool air is forced through an inner liner constructed of porous sheet material. To this end some promising work has been conducted at the National Gas Turbine Establishment towards the use of porous liners fabricated from closely woven and rolled wire mesh sheet.

THERMAL SHOCK

In the blading of aircraft gas turbines, conditions of rapid heating occur during take-off, while rapid cooling takes place during rapid deceleration, or in the event of an accidental fuel cut. The thermal shock is greater the higher the blade temperature. In uncooled engines, the gas and therefore blade temperature is progressively increasing in order to obtain higher thrusts, and so thermal shock tends to become more severe. A study of the factors involved and the effects produced therefore becomes increasingly necessary.

Such a study is in progress at the National Gas Turbine Establishment on ceramics and cermets (ceramic-metal mixtures) potentially useful for gas turbine blading, as well as on metallic alloys. Its main objects are to investigate the progressive damage and the mechanism of failure, and to determine the factors governing resistance to thermal shock. In the test rig, blade shapes are mounted in cascade and can be rapidly heated in high-velocity high-temperature gases followed by rapid cooling in high-velocity air at controlled rates and at pressures up to 10 atmospheres. To obtain the desired conditions of heat transfer, the cooling air is blown upward through a fluidised bed of fine powder.

Laboratory techniques have also been developed for the application of thermal shocks of controlled severity. Theoretical determination of the stresses from calculated temperature distributions have been made for simple shapes, e.g. cylinders; for a complex shape such as a turbine blade, advanced mathematical techniques are necessary. If the differential equations involved can be programmed for solution by automatic computing machines, it will be possible to recommend changes in blade shape that will reduce susceptibility to thermal shock failure. It is hoped the overall results of this study will provide information that will assist in the "design" of thermal shock-resistant materials for gas-turbine blading.

INTAKE DESIGN AND BLADE VIBRATION STUDIES

To study the effects of density changes on the performance of an axial compressor, a variable-density compressor rig is in service. The air passing through a model compressor under test is confined to a closed return circuit. The pressure in the circuit can be reduced to 0·1 atmosphere or increased to 4 atmospheres. A water cooler in the circuit keeps the air temperature constant, but no refrigeration is available. All the air in the closed circuit is dried.

The compressor under test is driven by an independent air turbine. The maximum speed is 30,000 r.p.m., giving a blade tip speed of 1,300 ft. per sec.,—well above current practice. The rig is controlled from a central control room. To keep testing time to a minimum, all readings are recorded photographically.

The rig has been used for a comprehensive series of tests into the effect of altitude on a single-stage compressor. It has also been used to study the loads on blades in a compressor due to vibration. A programme of work, in which the intake conditions to the compressor are varied in a manner similar to that expected at very high aircraft flight speeds, has just been completed. The rig is now being used for another blade-breakage investigation. Afterwards it is planned to examine the performance of a compressor designed for very high rotational speeds. A low air density will be used to reduce the blade loading as a safety measure.

TESTING COMBUSTION SYSTEMS FOR TURBINE ENGINES

In the past, common practice has been to use a number of "can" type combustion chambers, grouped around the central spine of the engine. Such an arrangement does not make the best possible use of space and weight, and the annular type of combustion chamber is now gaining favour (Fig. 9).

This necessitates an increase in the size of test plant required for the development of the combustion equipment since the whole annular chamber has to be tested whereas, with can-type chambers, it is sufficient to test one "can." Because the large air supplies required are not readily available at the manufacturers' facilities, annular combustion chambers are at present being tested mainly at Pyestock. The combustion chamber is first tested at pressures a little above atmospheric in order to correlate the performance as installed on the test rig with that previously determined by the manufacturer. The tests would then be continued to sub-atmospheric pressures to determine the effect on efficiency and stability (that is, the range of fuel-to-air mixtures that can be burnt) and on ignition characteristics. To obtain these conditions the plant air supply must be switched to drive ejectors which will draw off the combustion-chamber exhaust gases and reduce the pressure level in the combustion chamber. By

Fig. 8 The control station for the experimental air-cooled turbine.

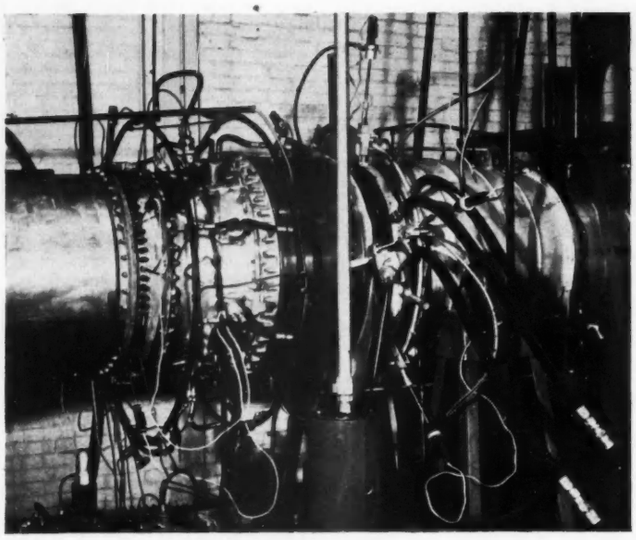


Fig. 9 Annular combustion chamber test rig.

suitable throttles and the use of by-pass pipes it is possible to control both the air pressure level in the chamber and the rate of air flow through it.

This rig is comprehensively protected against the danger of explosion: the fuel supply to the rig is automatically cut off (i) if the water blanket inhibiting the exhaust duct should fail; (ii) if the air supply should fail; (iii) if the flame, detected by an infra-red cell, should become extinguished.

The air pressure and flow and the rate of fuel supply have to be measured accurately, as does also the temperature at inlet and outlet from the chamber, in order that the efficiency of the burning process can be determined. Additional information on combustion efficiency can be obtained by chemical analysis of the exhaust gases. It is in fact necessary to determine the pattern of temperature distribution at the outlet section, both in order to obtain a representative mean value and also to ensure that the distribution is sufficiently uniform. Hot zones in the exhaust can result in mechanical damage to the turbine, which must follow the combustion chamber, and a stratified temperature distribution can result in a loss of aerodynamic efficiency in a turbine designed to accept a uniform distribution.

RAM-JET ENGINES

A ram-jet, essentially an engine for supersonic flight, has an air intake which scoops up a steady stream of air and slows it down to subsonic speeds, increasing the pressure and density of the air as it does so by the conversion of kinetic energy into pressure energy. Much of this conversion of energy is done through the agency of shock waves, the efficiency of the process being largely determined by the complexity of the shock pattern employed. Thus the family of inclined shocks created by a spike in the centre of the intake results in a greater pressure recovery than the single " bow-wave type " normal shock which forms in front of a plain-hole, or Pitot type, intake. The ram pressure ratio which can be obtained from an intake system increases rapidly with flight speed, so that whilst it is only possible to get a pressure ratio of about 1·8 when flying at the speed of sound, at three times this speed, say 2,000 m.p.h. in the stratosphere, a ram pressure ratio of 36 is theoretically available.

In this high-pressure air, normal fuel, such as kerosine, is burnt to raise the temperature of the air to the vicinity of 2,000 deg. C. Although some pressure is inevitably lost in this heating process, the heat energy added is such that when the hot exhaust gases are allowed to expand again through a correctly-shaped propelling nozzle they reach a velocity considerably greater than the velocity the air had when approaching the engine. Thus a given mass of air in passing through the engine is accelerated rearwards and the engine consequently experiences a reaction " equal and opposite to " this force.

There are thus no rotating parts in a ram-jet engine, apart from the fuel-pumping system which often runs from a miniature air turbine operating on ram pressure. One penalty paid for this sweeping simplification is the inability of the engine to produce any thrust until the flight speed is sufficiently high for worthwhile ram compression to be achieved. With a ram-jet designed for flight at speeds of the order of Mach 2, this lower limiting speed is about one and a half times the speed of sound, and below this speed some alternative means of propulsion must be provided. For a pilotless missile the obvious choice for this launching " boost " falls on quick-burning solid-fuel rockets which can be disengaged from the missile when a satisfactory speed has been reached.

A further penalty is in the size and cost of test equipment required for the development of ram-jet engines. From the nature of the engine it can only be tested either by flying it at supersonic speeds or else by simulating on the ground the extremely high air velocities and the low atmospheric pressures to which the engine is subjected in flight. In fact both methods of testing have to be used. Fig. 10 shows a telemetering test vehicle for flight-testing ram-jets, using detachable rockets to launch the vehicle.

Full-scale combustion chamber development is usually carried out by mounting the ram-jet combustion chamber at the end of a duct directly connected to the plant air supply. In this type of test the best forms of fuel injection and flame stabilisation equipment can be established provided that representative air flow conditions can be reproduced. By conducting these tests at air pressures of 40 to 50 lb. per square inch absolute, corresponding to supersonic flight at fairly low altitudes, the combustion equipment can be subjected to mechanical loadings comparable with the worst flight cases.

By fitting powerful hydraulic jacks to the valves controlling the air supply it is possible to reproduce the rapid rise of both air pressure and air flow which occur during the rocket launch of a ram-jet, and in this way fairly representative ignition trials can be carried out.

To test the combustion chamber at conditions corresponding to high altitude, where inevitably the problems of combustion are worse, even though problems of mechanical reliability are lessened, it is necessary to provide exhauster plant which can draw air through the combustion chamber at pressures considerably below sea-level atmospheric pressure.

In the free-jet wind-tunnel the complete engine is placed in a high-velocity air stream issuing from a convergent-divergent nozzle. Such a nozzle can be made to give a parallel air stream of effectively constant supersonic velocity, and provided that the engine intake is completely submerged in this stream, leaving some air to spill over the outside of the engine, the air flow within the engine can be assumed to be identical to that occurring in flight at the Mach number of the free air stream. Methods for varying the velocity of the free-jet air stream are in course of development, but are not yet in use.

FREE-JET ALTITUDE CELL

Although existing test plant is not adequate to test a full-size ram-jet at free-jet air speeds simulating Mach 2 flight, the problems involved can be studied by using smaller models. The high pressure ratio required to produce a high Mach number free-jet is obtained by letting the jet exhaust into a region of sub-atmospheric pressure (Fig. 11).

This is accomplished in an altitude test cell; a cylindrical chamber is connected at one end to an exhauster plant which maintains the pressure in the chamber at the required sub-atmospheric value. At the other end of the chamber air is delivered into the cell through a shaped nozzle which gives a jet stream of the required velocity blowing at the intake of the test model. In this installation flight at speeds up to Mach 2 and altitudes up to 40,000 ft. may be simulated.

The model is attached to a removable lid through which pressure tappings and other control and instrumentation equipment pass. The

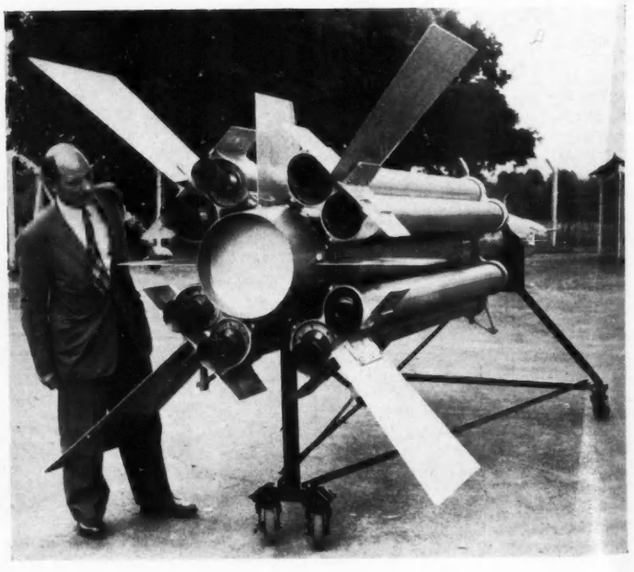


Fig. 10 Ram-jet test vehicle, launched by solid-fuel rockets which are jettisoned when the vehicle has attained sufficient speed for the ram-jet to sustain itself. Instrument readings are transmitted to the ground by radio.

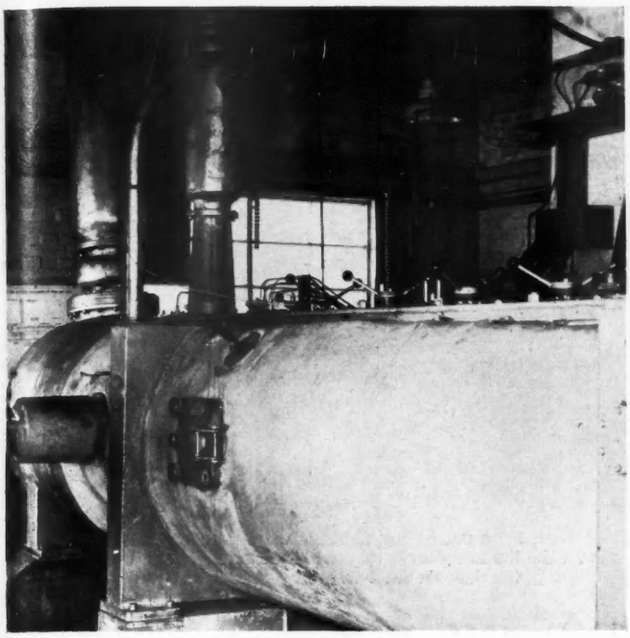


Fig. 11 Free-jet altitude cell for testing model ram-jets.

axial direction of the free-jet may be altered manually during running to simulate yawed flight. The shock-wave pattern at the intake may be observed and photographed during operation by means of a shadowgraph and spark-illumination system. The tests are conducted from the adjacent control room, and the readings may be recorded photographically.

A free-jet cell of this type enables the performance of intakes and combustion systems under simulated free flight conditions to be assessed, while the operation of the engine is under direct and constant control, and observations of performance may most readily be made.

Other investigations in progress at N.G.T.E. include research on the mechanism of spontaneous combustion; the response of turbo-jet control systems to rapid adjustments to fuel flow; the behaviour of convergent-divergent propelling nozzles for supersonic flight over a range of flight conditions; and a research compressor designed to operate at slightly supersonic blade speeds, to enable detailed flow patterns to be studied with a view to raising the speed at which the compressor efficiency drops off as a result of shock formation.

TEST INSTRUMENTS

In conclusion, it is interesting to refer briefly to some of the special test instrumentation in use at Pyestock.

Fuel/Air Ratio and Combustion Efficiency Meter.—For determining the fuel/air weight ratio and the combustion loss, an exhaust-gas analyser is at an advanced stage of development. A sample of combustion gases is subjected to a two-stage process. Firstly, the gases are completely burnt over platinum and copper oxide, and the resultant gross carbon dioxide content is measured by means of an infra-red gas analyser. Secondly, an identical sample is passed through a freezing trap to remove condensable constituents (fuel and water), and the net (existing) carbon dioxide, carbon monoxide, and hydrogen are measured by two infra-red gas analysers and a sonic analyser, respectively.

From these four quantities the required data can be calculated. A measurement takes some five or six minutes to complete. Measurements can be made at any fuel/air ratio up to 0·125 to 1 and at any combustion loss up to 100 per cent. (i.e., an unburnt fuel-air mixture). Means are provided for pumping sample gas from combustion systems running at simulated altitude conditions up to 50,000 ft., maximum r.p.m.

Circular Time-Base Speed Control.—In research on gas turbines, the accurate control and measurement of rotor speeds is of great importance. One method, at present under development, is the instantaneous comparison of the frequencies of electrical signals from a tuning-fork (constant frequency) and a small alternating current generator coupled to the rotor shaft (frequency variable with speed). The presentation, on a cathode-ray tube, is a pattern resembling a cogged wheel, stationary when the two frequencies are identical or in an integral ratio, and otherwise rotating clockwise or anti-clockwise. The aim is the maintenance of a stationary pattern, and the rotational presentation of an error in speed helps an operator to make instinctive manual correcting adjustments to a wheel control valve on, say, the compressed air supply to a turbine.

Suction Pyrometry.—For measuring gas temperatures, thermocouples are usually used; to bring the wires to gas temperature involves getting the maximum rate of heat transfer from gas to thermocouple and the smallest possible loss by radiation and conduction to the surroundings. The problem becomes more difficult at low gas densities under high altitude conditions.

The greatest accuracy is obtained by having as many gas molecules as possible striking the thermocouple in a given time, at the same time shielding and insulating it from cooler environments. In the "sonic suction pyrometer," the wires are fixed across a small nozzle, in a tube, through which the gas sample is sucked at the speed of sound. It gives great accuracy under all conditions and has a very small time lag when gas temperature changes occur. A miniature version of the sonic pyrometer is being developed for use in aircraft engines.

Tip Clearance Indicator.—An instrument for the continuous measurement of the blade tip clearance in compressors and turbines is required on turbo-machinery used in research, (*a*) for mechanical reasons (i.e., blade creep, thermal distortion, etc.) and (*b*) for accurately assessing all factors influencing the performance.

The probe unit, which consists of an electric motor and gearing, is mounted outside the compressor (or turbine). It slowly feeds an electrically insulated and charged probe towards the rotating blading. When the charged probe is within approximately 0·001 in. of the orbit of the largest blade, a spark passes and the amplifier reverses the motor to withdraw the probe a small distance. When no further sparking takes place, the probe with its condenser again fully charged allows the amplifier to reverse the control motor and the re-charged probe once more approaches the rotating blading. The probe thus hunts between sparking and not sparking on the blading.

A counter which is coupled by synchronous electrical links to the probe unit follows the movements of the probe to give a continuous reading of the gap between the fixed and rotating components.

* * *

INTERNAL COMBUSTION ENGINE RESEARCH

B.I.C.E.R.A. Report

The twelfth annual report of the British Internal Combustion Engine Research Association, Slough, has now been published; it covers the period from April 1, 1954, to March 31, 1955. In that time, nine reports of investigations have been published. The Council state that the financial position of the Association is giving much concern and the only long-term solution is an increase in membership. Recruitment of staff is also still proving difficult.

The Bicera formula for the stiffness evaluation of crankshafts has been checked on four more samples, one of them having dissimilar webs. Over 50 shafts with journal diameters ranging from 2·75 in. to 11·5 in. have now been checked in this way. Tests have also continued on couplings and clutches. The effect of injection timing on the harmonic components of gas-pressure torque is now under detailed consideration. The analysis of propeller damping coefficients has been extended to cover propellers of two, three, four and five blades (see ENGINEERING, vol. 179, page 594, 1955). Other work by the vibration panel is on amplitudes and stresses in identical engines, and on the effects of rubber-bonded dampers. A draft of the handbook on this subject is almost complete.

The group dealing with pressure charging has continued work on the Mirrlees TL 3 engine and on the Bicera compressor (ENGINEERING, vol. 179, page 189, 1955). Inquiries have been made with a view to obtaining a turbo-charger capable of producing high boost pressures. The questions of noise reduction are still the subject of investigation of one panel, and preliminary tests have been carried out on valve gear. Other work includes the investigation of combustion noise and the limitations of tape recorders employed in the investigation of noise.

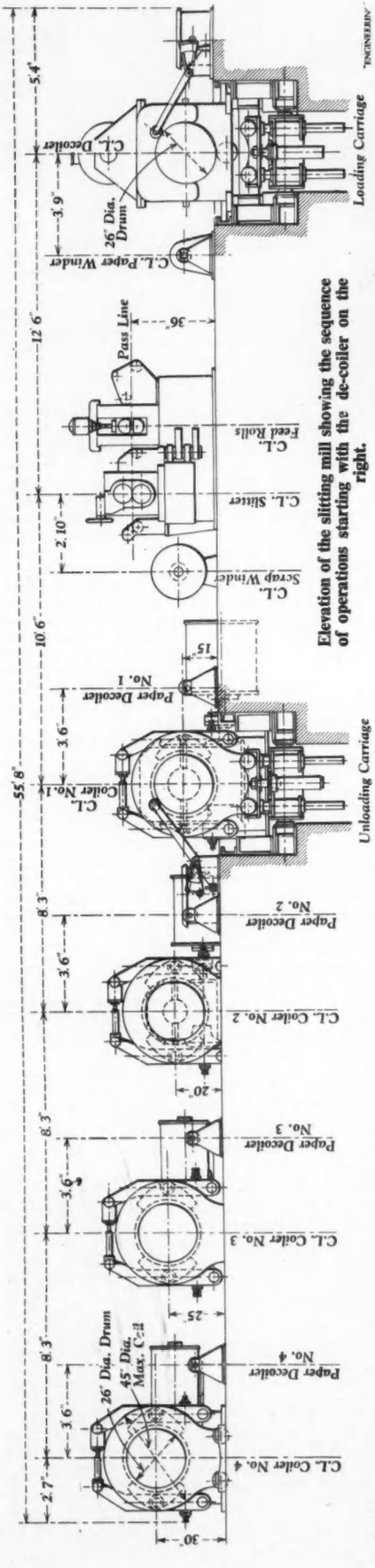
Other sections of the Association are continuing work on fuels and combustion, lubricants and bearings and various aspects of stress analysis. The gas-turbine advisory panel have made a report to the Research Committee, and general research has continued on fuel injection, gas flow, fuel rating and the design of instruments. A second Tangye VC1 engine has been obtained and installed and a considerable amount of new equipment acquired.

* * *

VIBRATING SCREENS

A range of heavy-duty two-bearing vibrating screens has recently been introduced by Pegson Limited, Coalville, Leicestershire. They will screen wet or dry sand, gravel, washed stone, ore or coal, and can be also used on occasion for scalping if there is not too much oversize material. Known as the Pegson-Telsmith "Vibro-King," there are single, double and triple-deck models with screen sizes from 8 ft. by 3 ft. to 12 ft. by 5 ft.

The main frame is made from channels and I-beams of alloy steel, reinforced at the corners. The vibrating mechanism, including the screen cloth, is mounted on springs. The vibrating unit is mounted on heavy-duty roller bearings and is fitted with counterweights to prevent any "jump" of the screen at critical speeds, resulting in a uniform circular motion of the whole screen cloth. Lubrication is by grease gun. If desired, rubber-protected trays can be fitted, and spraying equipment is also available for rinsing operations.



Stainless steel strip is de-coiled from the drum on the right and passes through the slitter to the re-coiling drums. Other drums handle the inter-leaving paper. The operations are controlled from the desk on the left.

SLITTING HIGHLY-FINISHED STAINLESS STEEL

PRECISION CUTTING FOLLOWED BY INSPECTION

The slitting mill is among the oldest of the metal-cutting machines, and it is still used extensively for both ferrous and non-ferrous metals. In basic principle the slitter is the same as it was when it was first introduced into this country in the late sixteenth century. Two contra-rotating spindles are mounted vertically one above the other and on them are fixed, at the desired spacings, a number of circular cutters the edges of which act as rotating shear-blades. If a sheet is fed into the machine the cutters, acting one against the other, split it into a number of strips, the process being continuous as long as sheet is passed between the spindles and the cutters are maintained in proper condition. That is the basic principle, but the machine has undergone many changes in detailed design, and to-day it is a high-precision tool capable of a considerable output. The pull-through slitting machine which, together with its ancillary equipment, is described below, is typical of modern practice, and it is noteworthy not only for the speed and precision with which it operates, but also for the care which has been taken in the design to ensure that there is no damage to the highly-finished surface of the material being cut. The equipment has been designed and built, together with an examination line which is used in conjunction with it, by W. H. A. Robertson and Company, Limited, Lynton Works, Bedford, and is installed in the Shepcote Lane Works, Sheffield, of Firth-Vickers Stainless Steels, Limited. The electrical equipment was supplied by the English Electric Company, Limited.

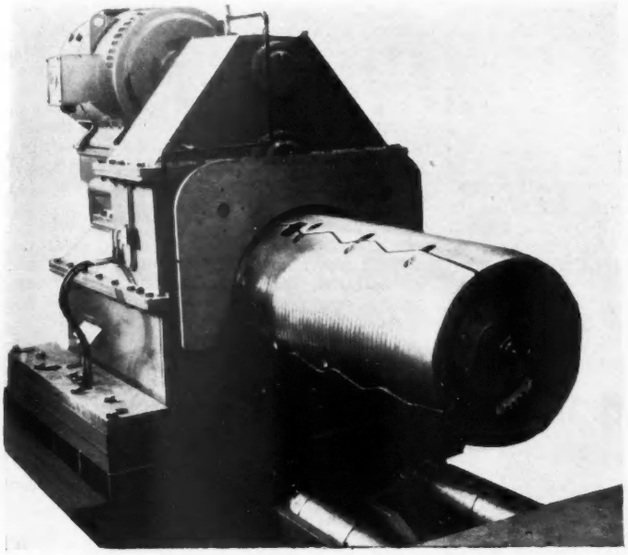
The slitting line is capable of dealing with wide stainless-steel strip in coils up to 5 tons in weight and 41 in. wide, the gauge varying from 30 to 16 s.w.g. It will make up to five cuts (giving four strips) in the maximum thickness at a speed of about 300 ft. per min. A smaller number of cuts can be made to produce wider strips, and two edge-trimming cuts only can be taken on strip of any width up to the maximum. The coils of stainless steel strip are received at the Firth-Vickers plant from the adjoining works of their associated company, Shepcote Lane Rolling Mills, Limited, interleaved with paper for protection of the surface. The slitting line comprises three units: a de-coiling stand, a slitting unit, and a coiler unit. The latter is equipped with four stands, so that up to four slit strips can be coiled simultaneously.

DE-COILING

The de-coil stand is of the overhung mandrel type, with a drum 26 in. in diameter and 42 in. net face width. A shaft machined from a high-tensile steel forging, mounted in spherical roller bearings, is used to carry the drum, which is of the collapsible four-segment type, with a maximum collapse of 2 in. The ends of the segments are tapered to facilitate loading of the coil. The drum is collapsed and expanded by means of a rotating air cylinder 16 in. in diameter mounted at the rear of the stand and coupled to the segments by a push-pull rod and toggles. The main bedplate is of fabricated steel, and is mounted in slideways on a sub-bedplate. It is provided with 3 in. of movement either side of the centre-line of the plant, so that the strip can be centred for run-off. Movement of the bedplate is by a hydraulic cylinder.

Coils of strip are transported to the de-coiler by an elevating pole-truck, and loaded on to a coil carriage. This consists of a traversing carriage with two rollers which support the coil as it is placed in position, the carriage then being at the outer limit of its travel. A vertical hydraulic cylinder, 5¼ in. bore and 16 in. stroke, built into the carriage, is used to raise the coil to the correct height for the drum, and the carriage is then traversed inwards, in channel guides, by a horizontal hydraulic cylinder of 5¼ in. bore and 60 in. stroke, to load the coil on to the drum. A sliding floor-plate is attached to the carriage to close the gap in the floor as the coil is loaded. The de-coiler is also equipped with a setting plate, which can be adjusted by manually-operated screws, and the drum, like all the others in the line, is marked with rings, machined on the surface at 1 in. intervals and numbered, to assist in correctly lining-up the coil and the strip throughout the plant.

The de-coiler drum is coupled by reduction gearing to a 20-kW drag-generator, which provides controlled back tension on the strip, and acts as a motor for feeding a new coil into the line. A motor-driven paper re-wind stand is mounted immediately beyond the de-coiler, to take up the interleaving paper as it is unwound from the coil of strip. The paper is wound on



The de-coiler drum is of the segmental, collapsible type, with a power-operated loading carriage. It will accommodate rolls of strip up to 41 in wide and 5 tons in weight.

to a cardboard spool, the friction drive between the shaft and the spool being sufficient to allow for the changing diameter of the paper roll.

SLITTING

The slitting machine is mounted at 12 ft. 6 in. centres from the de-coiler, and is equipped with a two-roll feed unit in front and a scrap winder behind.

The feed unit consists of two rubber-covered rolls mounted in ball and roller bearings, the lower roll being on fixed centres while the upper one is carried in chocks sliding in the housing windows and attached to compressed-air cylinders contained in the housing caps. Both rolls are driven by universal couplings from a pinion box on the bedplate. The drive to the pinion box is by roller chain from the slitting machine. An over-riding clutch is fitted in the drive to allow the rolls to idle when the slitter takes over and pull-through is in progress. Guide rollers are also fitted on both the ingoing and outgoing sides of the slitter, to maintain the horizontal position of the pass-line.

The slitting machine has 9-in. diameter cutters and a working width of 42 in. Both spindles are mounted on ball and roller bearings in eccentric cartridges, which are adjusted by spur and worm gearing to ensure that a constant pass-line is kept irrespective of the reduction of diameter of the cutters caused by re-grinding. The outer housing is arranged to slide clear of the spindle-ends. for removal of the cutter arbors. A manually-operated screw is used for withdrawal of the housing, which, in the outer position, swings clear on a pivoted extension of the main bed, to give free access to the spindles. Six cutter arbors are supplied, and the changing and re-arranging of the cutters is done away from the machine, which can continue in operation while this work is done. Spare sets of arbors and cutters can be kept ready assembled so that the change-over can be carried out quickly. The cutter arbors are of flame-hardened high-tensile steel, and they have bayonet-type ends to enable them to be fitted to the driving spindles without loss of time. For threading-up, the cutter spindles are driven by universal couplings through a pinion box and a fan-cooled reduction unit, from a 15-h.p. electric motor running at 960 r.p.m. This drive gives a threading-up speed of about 50 ft. per minute. A self-disengaging dog-clutch in the drive operates and frees the slitter when the pull-through commences. A hand-lever is provided for manual disengagement of the clutch when required.

At 2 ft. 10 in. centres from the slitter is a scrap winder, which is used for disposal of the ribbon scrap produced when edge-trimming. It consists of a single spindle with two tapered drums, driven by a slipping clutch from the slitter main drive gear. The outer flange plate of each drum is arranged for easy removal by means of a bayonet-type fitting.

COILING THE SLIT STRIP

The first coiling stand is at 10 ft. 6 in. centres from the slitting unit. This is followed by three more coiling stands, each at 8 ft. 3 in. centres. All four coiling stands are similar in design, but the first two after the slitter have drums 26 in. in diameter by 45 in. wide, while the remaining two have drums 26 in. in diameter by 33 in. wide.

The drums are of the segmental type, with one fixed and two hinged segments, the latter being controlled by cams on the drum shaft. To start coiling, the end of the strip is led manually into an eccentric gripper on the circumference of the drum, the drum is held by a compressed-air post-type brake, and the drive is started. The cam then drives the segments outwards to form a true 26 in. diameter circle, and holds the drum at this diameter as long as strip is being coiled on to the drum against the back-tension from the de-coiler. The brake is released when the drum is gripping, and is not used again until it is necessary to remove the coil. To do this the brake again holds the drum, and the drive is reversed. A heel on the cam then contacts a similar heel on the segment, and the drum collapses, leaving the coil free for removal. The drum shafts are mounted in roller bearings in heavy pedestals, and are driven by variable-speed direct-current motors through totally-enclosed, fan-cooled worm reduction units. The drive motors are rated as follows: No. 1 coiler, 0/40/40 h.p. at 0/600/1,200 r.p.m.; No. 2 coiler, 0/20/20 h.p. at 0/600/1,200 r.p.m.; Nos. 3 and 4 coilers, 0/10/10 h.p. at 0/600/1,200 r.p.m. This allows for the full coil to be taken on No. 1 coiler when edge-trimming; the remaining drums deal with the narrower strips when slitting.

Each coiler has an unloading carriage of similar design to that used for loading the de-coiler. A dancer roller working on the first coiler controls a rheostat which reduces the speed of the four coilers progressively as the coils build up. A maximum back-tension of 2,000 lb. can be applied to the strip from the de-coiler, and this can be taken up as follows: all on No. 1 coiler; 1,000 lb. each on Nos. 1 and 2; or 500 lb. each on Nos. 1, 2, 3 and 4. A paper-reel stand is provided on the ingoing side of each coiler to feed the interleaving paper, and there is a brake on each stand to provide the necessary tension on each roll of paper.

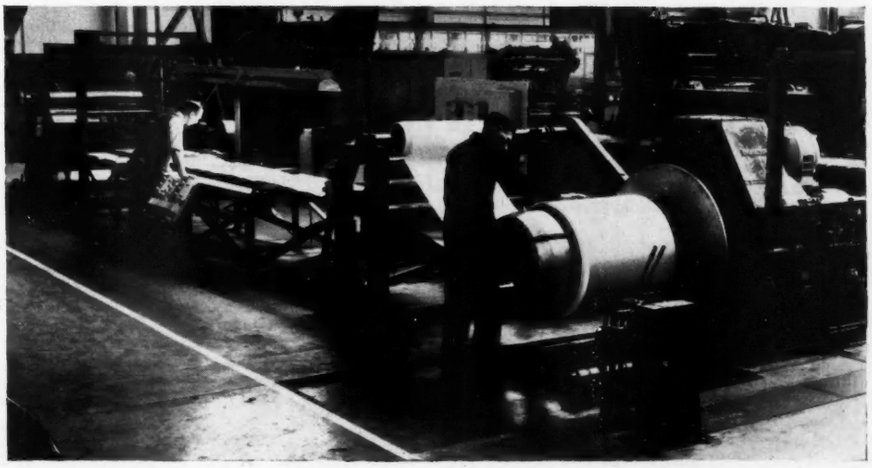
The main drive to the direct-current motors is from a motor-generator set, with Ward Leonard control to the drag-generator and the coiler motors. There is also a 15-h.p. squirrel-cage motor running at 960 r.p.m. to drive the hydraulic pumps, which operate at 1,000 lb. per square inch, and supply power for the slitting line and also for the adjacent inspection line. Control of the slitting line is from a desk installed opposite to the slitting unit.

INSPECTION AFTER SLITTING OR TRIMMING

The inspection line deals with coils of strip up to 5 tons in weight, 42 in. wide, and 0·080 in. thick at a variable speed of from 5 to 50 ft. per minute. It consists of a driven de-coiler, with coil-loading gear; a paper re-wind stand which incorporates guide-rolls; a paper unwind and guide-roll stand; and a single-drum coiler with unloading equipment. The de-coiling and coiling units are spaced widely apart to allow for inspection of the strip as it is unwound.

The de-coil stand is similar to that supplied for the slitting line, but it is driven by a 7½-h.p. motor running at 1,440 r.p.m. through a single-stage Heliocentric reduction gear and spur gears. This gives a threading-up speed of 50 ft. per minute. An air-operated dog-clutch is provided so that the drive can be disengaged for pull-through. Back-tension is provided by an air-operated brake. The paper re-wind stand has two rubber-covered guide-rolls, which run in ring-oiled bearings, and two paper re-wind drums. One of these drums is above the pass-line and one is below it, so that the paper can be wound whichever way the coil is being run-off. The drive to the paper re-wind spindles is by slipping clutch and roller chains from the de-coiler.

Immediately beyond the guide-rolls the strip



Examination of the strip is carried out on a line consisting of a de-coiler and coiler, with an examination table in between. A mirror shows the underside.

passes over a mirror, and thence across a table 10 ft. long; both sides can thus be examined visually for surface finish. A shorter table is next in line, and at this point a hand-operated electrically-driven nibbler can be used for cutting out butt-welded joints and for squaring-up ends.

The strip then enters a guide-roll stand, which incorporates a paper unwinding drum. This stand is similar to that used at the de-coiler end, but no drive is necessary for the paper drum. Following this stand is the coiler, which has a 26 in. in diameter by 45 in. wide, collapsible, four-segment drum, controlled by an air-operated push-pull rod through the centre of the shaft, and wedges on the segments. It is driven by a 10 h.p. motor running at 950 r.p.m. flexibly coupled to a Carter infinitely-variable speed gear, which is in turn flexibly coupled to a totally-enclosed worm gearbox. This drive gives a line speed of 5 to 50 ft. per minute, which is controlled as required by the operator at the inspection table. The drive is reversible to allow for over-coiling or under-coiling. Both the de-coiler and the coiler are equipped with loading and unloading carriages similar to those used on the slitting line. The inspection line is of Robertson manufacture, but the tables, mirror, fluorescent lighting and nibbler were supplied and installed by Firth-Vickers Stainless Steels, Limited.

EXTINGUISHING FIRES IN SHIPS

USING INERT GAS FROM OIL COMBUSTION

The extinction of fires in ships at sea and in port, particularly in cargo holds, is the subject of continual study both by shipowners and by the leading companies in the fire-protection industry. The Ministry of Transport on its part issues stringent regulations which must be observed by all British shipowners, and corresponding regulations are enforced by other maritime nations.

Further advances are now being made which employ non-toxic inert gas to extinguish a fire, the gas being continuously evolved from a special producer unit and consisting of the combustion products of Diesel oil.

The particular advantages claimed for this system are:—(1) that, using a self-contained generating unit, it does not rely on storage limited in capacity by space and weight; (2) that the supply of extinguishing gas is virtually inexhaustible; (3) that the system can be tested operationally at any time; and (4) does not depend on the re-supply of charges after use which may give rise to delay at ports where supply facilities may be lacking or difficult.

The prototype, which has been approved by the Ministry of Transport subject to final acceptance trials, is being introduced in a new ship now under construction for the Elder Dempster Lines, Limited, by Harland and Wolff, Limited, Belfast, the major part of the initial development having been conducted by the owners. As a means of providing the inert gas, the installation employs a water-jacketed refractory-lined combustion chamber incorporating a blower. This combustion unit is supplied by W. C. Holmes and Company, Limited, of Huddersfield.

The engineering layout and operating technique will be under the direction of the Pyrene Company, Limited, Great West-road, Brentford, Middlesex, who will undertake home and overseas marketing arrangements of future installations employing the system, which will be known as Pyrene E.D.-Hol.

In the system now being installed at Belfast, the gas-producing unit is a modification of a machine now largely used for rendering inert the atmosphere in chemical-process plant and gas undertakings, for preventing fire and explosion. The use of combustion products for this purpose is well established and once the plant is acquired and installed, inert gas can be produced relatively cheaply.

The composition of the gas, as determined by standard tests, is as follows: oxygen, 0-1 per cent.; carbon monoxide, nil; carbon dioxide, 15-14 per cent.; unburnt hydrocarbons, less than 0·1 per cent.; oxides of nitrogen, 0·01-0·015 per cent.; nitrogen, remainder, 85 per cent. The principle of the system can be followed from the accompanying layout diagram.

In the plant now being installed, the gas is delivered directly from a contact cooler, from which it emerges at a temperature slightly above that of the cooling water. There is no carry over of water droplets, and therefore the cargo will not be damaged by moisture.

The generator itself is about 9 ft. long by 4 ft. wide, and can be arranged to fit between decks. It consists of a horizontal combustion chamber, water-jacketed and refractory-lined. At one end are the burner and air-mixing arrangements, and the other opens directly to the foot of the cooling chamber. From this the gas passes upwards through a Lessing-ring labyrinth over which water is sprayed, the cooled gas leaving near the top of the chamber through a side connection. On top of the combustion chamber is mounted a Diesel engine driving the air blower, the water-service pump and the fuel pump. Pressure-relief valves are fitted on the air and gas side and air-control valves on the burner are marked with " start " and " running " positions.

The fuel is Diesel oil, and is kept at constant pressure by means of a governor valve, the quantity used being controlled. The engine uses the same fuel, and the total consumption to meet Ministry requirements for a 10,000-ton cargo ship, the largest hold of which has a " grain " capacity of about 115,000 cub. ft., would be approximately 25 gallons per hour.

The pump is arranged to supply the cooling water, and alternatively, can supply the two independent jets required by the Ministry of Transport to meet their regulations as an alternative to the engine-room pumps. The inert gas can further be led into the engine room in support of these water jets.

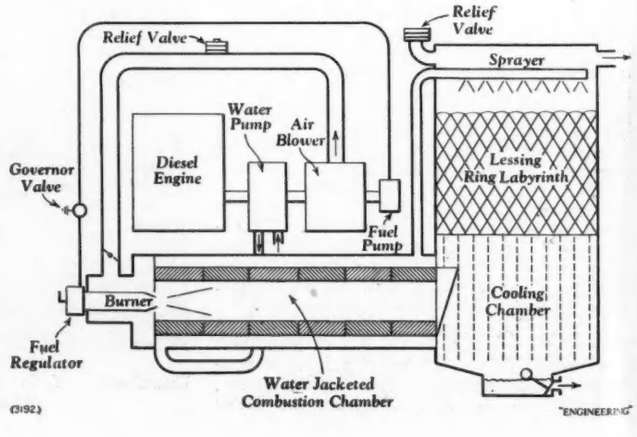
A control panel is fitted giving visual and audible indications if the system becomes out of balance, and if the carbon-dioxide content of the inert gas should fall below the normal 15 to 14 per cent. This control panel is also fitted with a continuously-reading carbon-dioxide indicator, which will, under operating conditions, enable the carbon dioxide to be kept to a maximum. The operation of the system is extremely simple and can be conducted by a junior engineer.

It is not proposed to use salt water cooling except in case of fire. A fresh-water supply will be arranged for use when testing, and the generator itself can be tested on atmospheric discharge without delivering the inert gas to the holds; the system as a whole can be tested conveniently when the holds are empty. In fact, one of the principal features of the new system is that it can easily and frequently be tested completely.

The advantage claimed is that the supply of inert gas itself is effective and does not damage the cargo, and that it is virtually unlimited in quantity and can be used to render inert spaces adjacent to that in which the fire outbreak has occurred.

The plant is simple to operate and easy to test and maintain, and when operating does not require rigorous battening-down arrangements. In addition, the cooling-water pump can be used as an independent fire pump if required.

As at present, the distribution system for the inert gas can be used as part of the smoke-detecting installation, or, as an alternative, ventilation of the holds can be effected through the same distribution piping.



In the Pyrene E.D.-Hol system, the cooled combustion gases from a Diesel fuel-oil burning combustion chamber are used to extinguish burning cargo and to render adjacent spaces inert. The air blower and fuel pump supplying the combustion chamber and the cooling-water pumps are driven by a Diesel engine.

★ ★ ★

FLEXIBLE COUPLINGS FOR SHAFTS

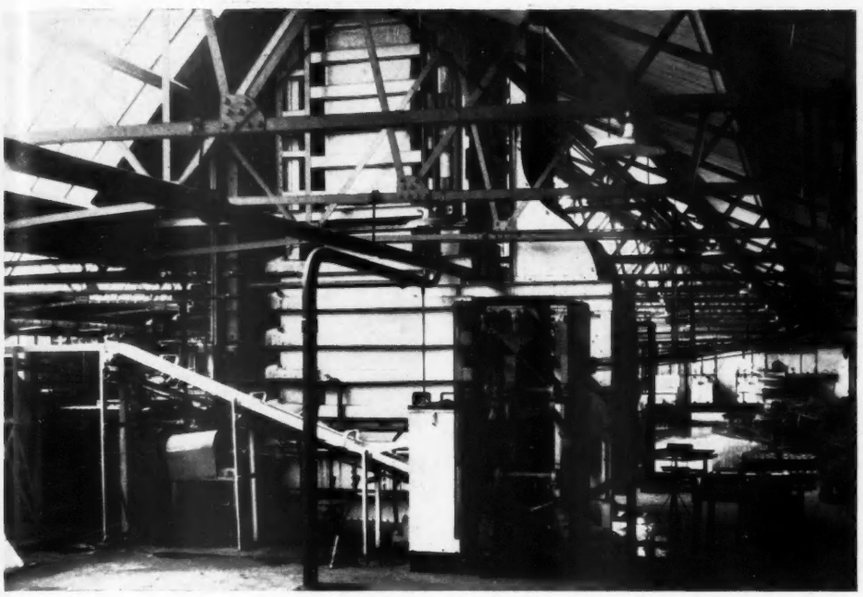
Rubber and Metal Types

To cater for the increasing demand for flexible couplings, Crofts (Engineers) Limited, Bradford 3, have introduced three new models.

The " Block " type coupling consists basically of two hubs between which is the resilient unit, consisting of two plates each with projecting dogs with rubber blocks compressed between the dogs. A protective casing covers the resilient units. Fourteen sizes are available, the largest being able to transmit 1,750 h.p. at 100 r.p.m., with a maximum running speed of 850 r.p.m., There are also variants available for the direct driving of brake drums or flywheels, and for other purposes. Initial compression of the rubber prevents the occurrence of backlash, and the construction allows for some end float. Fitting and removal are easy, as the centre unit is simply unbolted from the hubs and withdrawn sideways without disturbing the shafts or the bearings. No lubrication is needed.

The " Uniflex " coupling is also of the sandwich type, but instead of rubber there are two metal membranes. These are each held between two plates and the complete assembly sandwiched between the driving hubs. The drive is transmitted by pins on the hubs, which are long enough to pass into free holes in the opposite half so that the drive will be maintained even if one of the membranes fails. This series of couplings—there are 11 sizes—will transmit up to 450 h.p. at 100 r.p.m. They are suitable for speeds from 12,850 to 1,960 r.p.m.

The "NT" series are internal gear couplings and are redesigned versions of the MB series. Two forms are available—the first in which both driving and driven members have external teeth mating with internal teeth on a sleeve, and the second in which there is only one engagement. Power transmission ranges from 3 to 800 h.p. at 100 r.p.m.



The Mitchell-Webster Hydron hydrostatic steriliser has an output of from 200 to 600 cans per minute over a wide range of can sizes.

HYDROSTATIC STERILISER FOR CANNED FOODS

HIGHER QUALITY, GREATER OUTPUT

A new type of steriliser for canned foods which results in a pack of higher quality, as well as in considerably greater outputs than the standard equipment in current use, has been developed by Mitchell Engineering, Limited (Food Machinery Division), 7 Gower-street, London, W.C.1. In developing this machine, known as the Hydron, a close liaison has been maintained with the Fruit and Vegetable Canning and Quick Freezing Research Association, who have offered considerable technical assistance and advice in the researches into the processing of vegetables and fruits.

The Mitchell-Webster Hydron, a general view of which is shown in the accompanying illustration, is a " hydrostatic " steriliser, i.e., a machine employing a column of water, the height of which exerts a pressure at its base which is equal to the steam pressure within the steam compartment where sterilisation is carried out. By this means, the danger of sudden changes of pressure and temperature during the initial cooling or " bringing down " stage that can destroy the quality of delicate fruits and vegetables is eliminated. No mechanical valves are employed.

The height of the " Hydron " varies according to the maximum temperature of operation required—for 240 deg. F. it stands about 35 ft. high and for 250 deg. F. about 45 ft. high, and covers a floor area about 15 ft. square. Working on canned garden peas the output ranges from 200 to 600 cans per minute over a wide range of can sizes. Similar but rather smaller machines working at lower temperatures for fruit processing give outputs ranging from 65 to 520 cans per minute.

The sequence of operation of the Hydron is shown in the accompanying illustration. Filled cans are fed from the seamer at about 170 deg. F., delivered to the single or twin feed mechanism and enter the preheater section of the machine where they are heated to about 185 deg. F. They then enter a water seal, the water at this level being at approximately the same temperature. Passing down the " bringing-up " leg of the machine the temperature and pressure progressively increase to the maximum required, i.e. about 240 deg. F. at the water seal to the steam compartment. The cans then enter the steam compartment without encountering sudden changes in conditions either of external or internal processing temperatures or pressures, are held at the required temperature for a specified period and finally pass back into the water seal and ascend the " bringing-down " leg, where the temperature and pressure are progressively reduced to the top of the outlet water seal.

After the partially cooled cans break surface at the top of the outlet water seal, a short period of air cooling follows to make sure that the pressure reduction within the can is complete. Intermittent spray cooling continues with a further period in a cooling pit in which the cans are totally immersed in water. The cans are then discharged to packing tables at a temperature of approximately 95 to 100 deg. F.

A principal feature of the hydrostatic system is that the internal and external pressures and temperatures acting on the can are automatically synchronised throughout the whole process thus preventing sudden and damaging changes. The shape and position of the container during its passage through the process is also important since it is essential that the pack is allowed free movement to encourage free flow of convection currents. By conveying the can with its longitudinal axis in the horizontal plane, as in the Mitchell-Webster system, the tendency to packing or compression of the product in the base of the can is avoided.

SIMPLE FEED AND DISCHARGE

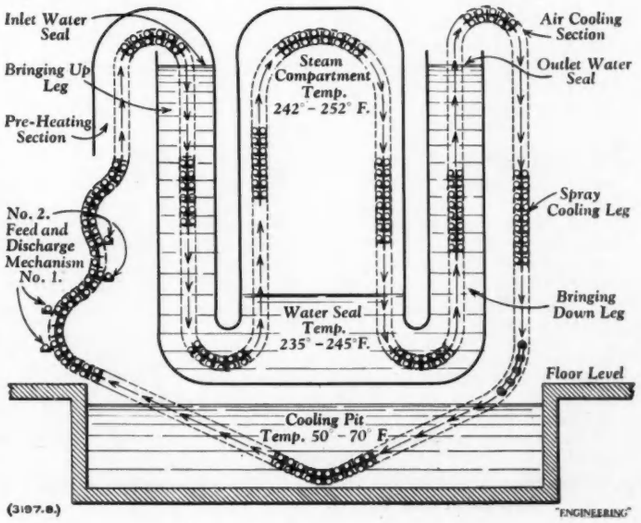
The twin-feed and discharge mechanism, remarkable for its simplicity of operation and construction, operates in synchronisation with the vertical movement of the can carriers. It consists simply of an endless belt running over two large-diameter pulleys, the top being the feed level and the bottom (and reverse side) the discharge level. The moment of feed and discharge is controlled by the can carrier in conjunction with a can-interrupter device operated by the main chain.

The can carrier is of the endless type consisting of a series of beams of special section which carry the cans in double rows, each row containing about 12 to 14 cans end to end. These beams, of non-corrosive material, are bolted to twin-roller chains operating in a track to convey the cans in a horizontal attitude in a continuous, non-agitating and controlled manner throughout the entire process. With cans 24-28 abreast per double row, the chain speed through the machine is reduced to approximately 3·5 ft. per minute, compared with about 50 ft. per minute in a normal single-track machine. This very slow speed obviates the risk of mis-feed and even if this should occur it cannot interrupt the operation of the steriliser or cause a jam.

Each loop of chain within the machine is driven by means of inter-connected spurgears mounted at the top of the steriliser, reducing chain wear and stretch to very fine limits.

Particular care has been taken in the design to ensure ease of maintenance. Access is provided to the whole of the interior of the machine for inspection and cleaning. All bearings are external, thus minimising lubrication problems. With the exception of the can carriers, all parts used in the machine are of standard design and are available in most parts of the world.

Extensive proving trials have been carried out on the steriliser with both fruit and vegetable packs which, the manufacturers state, have established that the Mitchell-Webster hydrostatic system is capable of producing packs of very high quality. The capacity of the unit and the range of can sizes handled, economy of steam and water consumption, and mechanical reliability are also very good. In 23 days, 3½ million cans have been sterilised in non-stop operation without mechanical faults.



In the Hydron, the filled cans are conveyed to the steam steriliser down through a column of water in which temperature and pressure is progressively increased. Similarly, they leave the steriliser travelling up through a column of water so that their temperature and pressure are gradually reduced before they enter the cooling section.

UNIFIED BOILER CONTROL AT EAST YELLAND

By H. Dickin, GRAD.I.E.E., A.R.T.C.(SALFORD)*

Unified control has been applied to a large number of boilers, both at home and overseas, during the past 20 years, and one of the latest stations to use this system is that at East Yelland† in the South Western Division of the Central Electricity Authority. When completed this station will have an installed capacity of 180MW, the plant consisting of six turbo-generators using steam from a common main at 625 lb. per square inch and 800 deg. F. The steam will be generated by eleven 180,000 lb. stoker-fired boilers, all of which will be equipped with the Metropolitan-Vickers unified boiler-control system.

Basically, the system comprises Ward Leonard control with direct-current motors having special inherent characteristics. They are compound-wound and their speeds are matched so that at any applied voltage they will run at the correct speed for optimum combustion conditions. In earlier installations direct-current was obtained from motor-generators, but modern practice is to use grid-controlled mercury-arc rectifiers owing to their higher overall efficiency and lower maintenance costs.

ARRANGEMENT OF SYSTEM

A simplified diagram of the system at East Yelland is given in Fig. 1. As will be seen alternating current is supplied from the station auxiliary busbars through the oil circuit-breaker *a* and the rectifier transformer *b*, to the main rectifiers *c*. Direct-current from these rectifiers is then transmitted to the common variable-voltage busbars *d* through a circuit-breaker *e*. The armatures of the motors driving the induced-draught fans, forced-draught fans and stokers are connected to these busbars through high rupturing capacity fuses *f*. The armature circuits of the forced-draught fans have separately controlled single-pole contactors *g*, and in the armature circuits of the stoker motors are hand-operated starters *h*.

The fields of the motors are connected through the rheostats *i* and links to the constant-voltage busbars *k*. These busbars are supplied with direct-current from a small metal rectifier *l* which, as will be seen, is connected to a tertiary winding on the rectifier transformer. Between the rectifiers and busbars are three fuse-holders *m*, and connected to two of these is another set of busbars known as the "transfer bars" *n*, which are common to all boilers. By suitably arranging the fuses in the holders it is possible to supply any boiler with power from any rectifier equipment; and also to supply two boilers from one rectifier equipment.

As unified boiler control consumes little energy and since the power demand of a fan is proportional to the cube of its speed, two boilers operating at approximately 80 per cent. of the maximum continuous rating can be operated from the rectifier equipment of one boiler. Thus, as illustrated, in Fig. 2, the system provides its own standby.

* Mr. Dickin is with the Metropolitan-Vickers Electrical Company, Limited.

† ENGINEERING, vol. 179, page 534 (1955).

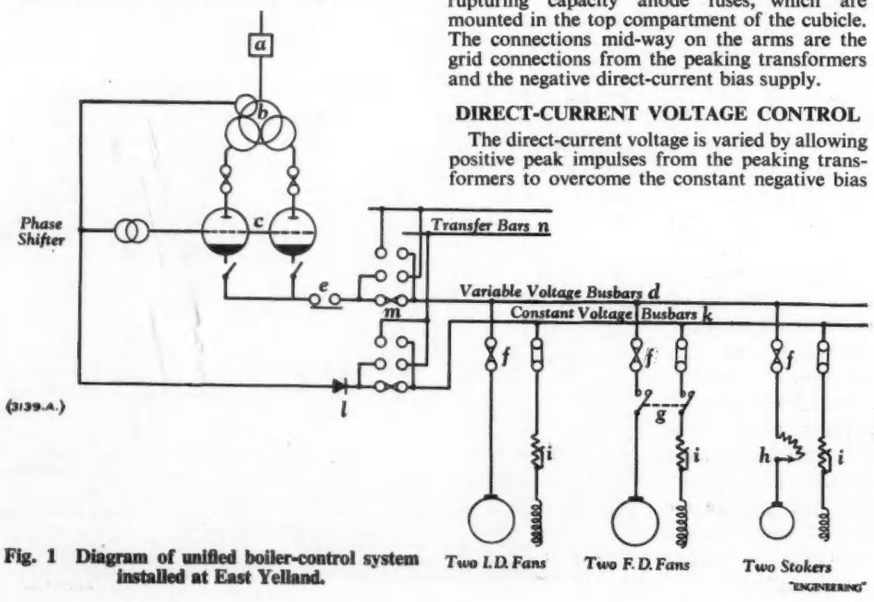


Fig. 1 Diagram of unified boiler-control system installed at East Yelland.

RECTIFIER EQUIPMENT

The rectifier transformer shown at *b* in Fig. 1 is a 3·3 kV, 470 volt three to six-phase unit with two fork-connected secondaries and one star-connected 15 kVA, 110 volt, three-phase tertiary winding. The primary connection is through a cable box suitable for a paper-insulated, lead-covered steel-wire-armoured cable, the secondary connections being through studs to which the varnished cambric anode cables are secured. The transformer is mounted in a covered cell with an open front. One side of this cell forms a dividing wall between the transformer and its associated rectifiers, thus keeping the anode connections as short as possible.

There are two main rectifiers per boiler, shown in Fig. 3. Between the two rectifier cubicles is the direct-current circuit-breaker panel and below the circuit-breaker are fuses which split up the 110 volt alternating-current supply from the tertiary winding of the transformer. This winding supplies the control and ignition circuits of the rectifier, the common peaking transformers and the phase-shifter for grid control, the rectifier cooling fans (at the bottom of the cubicle), and the 10 kW, 130 volt metal rectifier, which energises the direct-current motor fields. This metal rectifier is mounted at the rear of the circuit-breaker panel, and the motor-driven phase-shifter is behind one of the cubicles.

As will be clear from Fig. 3, the main rectifiers are of the glass bulb grid-controlled type. The connections at the ends of the protruding arms are the anode connections from the high-rupturing capacity anode fuses, which are mounted in the top compartment of the cubicle. The connections mid-way on the arms are the grid connections from the peaking transformers and the negative direct-current bias supply.

DIRECT-CURRENT VOLTAGE CONTROL

The direct-current voltage is varied by allowing positive peak impulses from the peaking transformers to overcome the constant negative bias applied to the grids, thus permitting the anode affected to strike an arc to the mercury-pool cathode. The phase displacement between the anode wave form and the positive grid impulse determines the instantaneous value of the anode voltage at which it strikes and hence the direct-current voltage. This phase displacement is determined by the position of the secondary winding of the phase-shifter which is a one-to-one ratio transformer in which the secondary can be rotated through 105 deg. in two minutes. The combined output from the two bulbs is 365 kW, and to ensure load sharing, each rectifier is connected to a separate winding of the transformer. Grid control gives a smooth variable voltage from 0 to 550 volts.

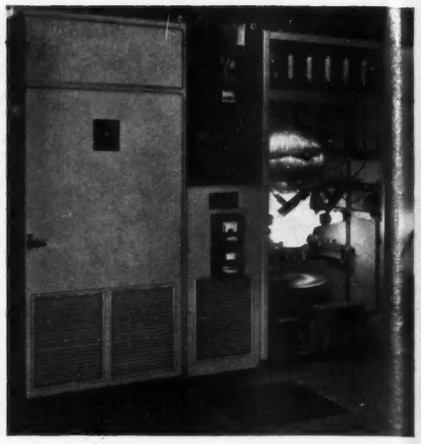


Fig. 3 View of rectifiers, two of which are provided for each 180,000 lb. boiler.

The open-type direct-current board, which is illustrated in Fig. 4, forms the link between the rectifiers and the motors. It is installed near the rectifiers and, like them, is located in a room separate from the boiler house at firing-floor level. Since the induced-and forced-draught fan motors are in the basement immediately below the rectifier room this enables the cable runs to be kept to a minimum. The individual motor fuses are located on the lower end panels, and the forced-draught fan motor contactors on the upper end panels.

The transfer fuses are mounted on the lower centre panel and immediately above these are the "control transfer switches." The purpose of these is to control the rectifiers and their associated oil circuit-breaker from the panel of the boiler that is in use, irrespective of which equipment is being used to supply a particular boiler.

MOTOR DESIGN

The direct-current motors are separately excited, shunt-wound, series-stability, compounded machines with special speed/armature-voltage characteristics. The induced-draught

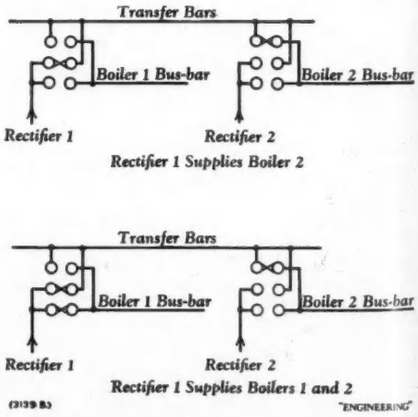


Fig. 2 Diagram of stand-by arrangements.

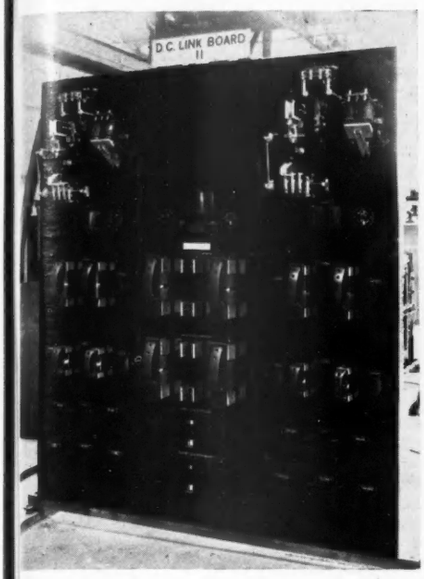


Fig. 4 Direct-current link board between rectifiers and motors.

fans are driven by 180 h.p. motors, the forced-draught fans by 65 h.p. motors, and the chain-grate stokers by 3½ h.p. motors.

The secondary-air fans, which do not require a variable-speed drive, are driven by 31 h.p. constant-speed direct-on start squirrel-cage motors.

The fan motors are not of the totally-enclosed pattern generally used in boiler houses, but are pipe-ventilated, specially designed dry filters being fitted on the inlet. A manometer connection on the short trunking to the filter enables tests to be made to decide when cleaning is necessary. The use of these filter-ventilated machines has proved very satisfactory and the motors have run without trouble since their installation. Two of the fan motors are shown in Fig. 5.

PROTECTIVE ARRANGEMENTS

The rectifier transformer windings are protected from rectifier surges (which may be induced by arc starvation when starting from cold) by "Metrosil" surge diverters which are mounted in the rectifier cubicles. A static earthing device connected to the transformer neutral (direct-current negative) gives protection against failure of the high-voltage insulation. The anode fuses provide short-circuit protection to the transformer secondary windings when "back-fires" occur owing to overheating of the anodes, caused by persistent overloading or failure of the rectifier cooling fan.

The direct-current circuit-breaker is fitted with normal over-current release. The individual motors are protected by high rupturing capacity fuses which are mounted on the direct-current link board. These fuses also serve as motor isolators. The transfer fuses give additional short-circuit protection and also provide a convenient and rapid means of transfer when required.

Since the direct-current system is unearthed a single earth fault will merely earth one side of the system. A simple means of earth-fault detection is provided by two lamps connected in series across the busbars with the common connection between the lamps earthed. A difference in brilliance between the two lamps indicates an earth, the healthy busbar being connected to the brighter lamp.

External system disturbances which give rise to voltage fluctuations or a momentary complete loss of voltage on the station auxiliary busbars (and sometimes cause alternating-current motors to fall out of step, thus shutting down plant when it is most needed) have no effect on the system. For sustained faults, however, time-lagged under-voltage relays are fitted. These will operate on a fault which causes the voltage on the constant-voltage direct-current busbar to fall to half the normal value for a period greater than two seconds. The operation of this relay trips the rectifier oil circuit-breaker and automatically runs the phase-shifter back to the zero volts position in readiness for re-starting.

Fig. 5 View of fan motors.

OPERATION AND CONTROL

The simple starting and operational procedure is as follows: the operator closes the oil circuit-breaker *a* in Fig. 1 by means of a control switch on the boiler-control panel. An interlock will prevent this from being done if the phase-shifter is not in the zero-volts position (as indicated by a white lamp). The closing of the oil circuit-breaker automatically excites the rectifiers, making them ready for use.

The induced- and forced-draught fans are next brought up to the required speed for lighting up the boiler by turning the phase-shifter control switch to the "raise" position. When the fire is established the stoker motors are started independently by the hand-operated starters. The boiler is then brought up to the correct pressure and temperature for connecting to the range, the operator adjusting each motor speed independently by the individual field rheostats or "trimmers" to obtain the correct combustion conditions. The secondary-air fans are started as and when desired.

Further load changes can then be effected by operating the phase-shifter control switch only. This changes the value of the variable voltage and alters the speeds of the direct-current motors in unison, each following its built-in speed/boiler load characteristic. The acceleration of the direct-current motors is such that their response is always equal to the maximum rate of change of load of which the boiler is capable, hence load changes are effected smoothly and in the minimum time without loss in efficiency.

In the event of a boiler tube bursting, the forced-draught fan contactors are tripped and the induced-draught fans are run up to their maximum speed, so drawing all the sulphurous gases and steam up the chimney.

The controls for the oil circuit-breaker, phase-shifter, forced-draught fan contactors and secondary air fan motors, the stoker motor starters, and the trimming rheostats, together with a variable-voltage voltmeter and the individual motor ammeters are mounted on the boiler-control panel, a general view of which is given in Fig. 6.

In common with other unified boiler-control installations the auxiliary power consumption of this plant is low and compares very favourably with other modern boiler-control systems.

The consulting engineers for East Yelland power station were Messrs. Preece, Cardew and Rider, Queen Anne's Gate, London, S.W.1. The main contractors for the boiler plant and auxiliaries were John Thompson Water Tube Boilers, Limited, Wolverhampton, and the dust filters on the motors were supplied by James Howarth and Company, Limited, Farnworth.

The author wishes to record his thanks to Metropolitan-Vickers Electrical Company, Limited, and the Central Electricity Authority for permission to publish this article.

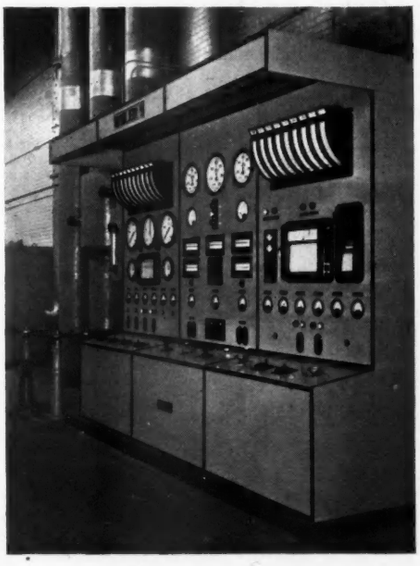


Fig. 6 Panel from which the system is controlled.

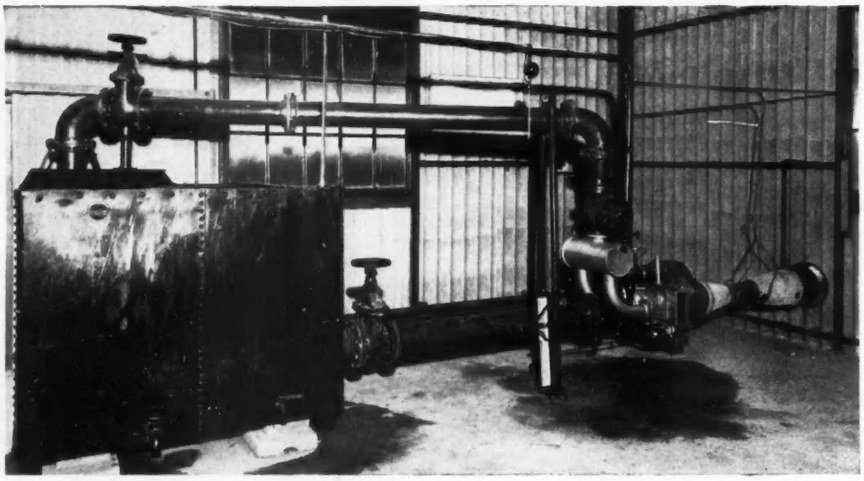
* * *

180 MW POWER STATION FOR HONG KONG

A new 180 MW power station, to be known as North Point B, is to be erected alongside the existing plant of the Hong Kong Electric Company, Limited, and is expected to be capable, when it is completed, of meeting the electrical demands of the island for the next 20 years.

The main contractors for the work are the English Electric Company, Limited, Kingsway, London, W.C.2, the sub-contractors being George Wimpey and Company, Limited, Hammersmith Grove, London, W.6, for the civil engineering work, Babcock and Wilcox Limited, Farringdon-street, London, E.C.4, for the steam-raising plant, and British Insulated Callender's Cables, Limited, 21 Bloomsbury-street, London, W.C.1, for the cables.

Preliminary work on the site has already begun and the plant will initially consist of one 30 MW set which will be supplied with steam at 600 lb. per square inch and 850 deg. F. The generating voltage will be 11·8 kV, which will be stepped up to 22 kV in a 37·5 MVA transformer for distribution to the island network.



The Rover IS60 shaft turbine, under test, pumps water through a calibrated closed circuit. By measuring water flow and delivery pressure, the shaft power can be determined.

NEW TEST HOUSE FOR SCHOOL OF GAS TURBINE TECHNOLOGY

To provide test-running experience for students on the intensive practical and post-graduate design courses in industrial and aircraft gas turbines which are run by the School of Gas Turbine Technology at Farnborough, Hampshire, a new test house has recently been brought into use at Pyestock. Test running has always been a feature of the school's courses, but until recently the test plant was housed in the Napier works at Acton, London, which meant a time-consuming journey for the students. Moreover, when the test plant was installed at Acton it was not possible to obtain an industrial gas turbine suitable for the purpose, and both aeronautical and industrial students were instructed on a Napier Naiad turbo-propeller.

In the new Pyestock test house, a Rover IS60 small industrial shaft turbine (shown above) has been installed to serve the industrial courses, and an early version of the Rolls-Royce Derwent turbo-jet is provided for the aeronautical students.

The Rover gas turbine drives a pump which pumps water through a calibrated closed circuit from a 500-gallon storage tank. This provides an economical means of determining the power output of the engine from measurements of the delivery pressure and the water flow, which is obtained from an orifice plate. This installation is hand-started and the load is controlled manually from within the test cell.

The Derwent engine, on the other hand, is started and controlled from the observation room in which is situated the instrumentation for both power plants. The turbo-jet thrust is measured hydraulically by means of a thrust pad arrangement, the engine being suspended on swinging links from the supporting framework. The throttle is controlled through a hydraulic transmission system.

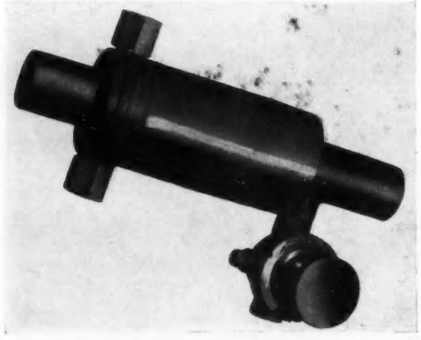
Large double-glazed windows are provided in the observation room, which is effectively sound-proofed. The instrumentation is dispersed about the room on three walls so that groups of several students are able to see and read the instruments easily. In addition to the standard temperature and pressure measuring instruments, fuel flow meters and tachometers, there is, on both test installations, provision for timing with a stop watch a set number of engine revolutions, by means of a geared cam which actuates a solenoid. The solenoid controls the stop watch.

AIR-DRIVEN HYDRAULIC PUMP

A junior model of their Airhydropump has been introduced by the makers, Charles S. Madan and Company, Limited, Vortex Works, Altrincham, Cheshire. It is shown in the illustration on the right.

The operating mechanism consists of a double-acting piston driven by compressed air, which is coupled to a solid ram forming the hydraulic pump. Inlet and delivery valves are fitted in the hydraulic section, and the pump will continue to operate until the load on the ram equals the compressed-air load on the piston. Since the relative area of the air piston is much greater than that of the ram, it follows that the hydraulic pressure produced by the pump is much greater than the air pressure supplied. In fact, in the Junior model an air pressure of 100 lb. per square inch will give a hydraulic pressure of 10,000 lb. per square inch. Once the load balance has been reached, there is no further movement of the piston, and the pump will maintain the hydraulic pressure without the consumption of any more compressed air.

A reducing valve on the air inlet controls the final pressure given by the pump. Operation can be obtained from any air line as long as the pressure is between 20 and 100 lb. per square inch. The materials used in the construction will not corrode, and either water or oil can be used in the hydraulic circuit. There are no metal-to-metal moving parts. The pump is suitable for testing valves and small fittings of most types, and being small and light it can be used anywhere. It is also capable of acting as a power supply for operating small presses, rams or hydraulic jacks. It measures 12 in. long by 3¼ in. in diameter and weighs 16½ lb.



Using a double-acting air piston, the Junior Airhydropump can produce hydraulic pressures of 10,000 lb. per square inch from an air supply at 100 lb. per square inch.

PNEUMATICALLY OPERATED CLEANSING TANK

Di-phase Solutions

A range of di-phase metal cleansing machines has been introduced by Electro-Chemical Engineering Company, Limited, Queens-road, Weybridge, Surrey.

Known as Agidip, they are pneumatically operated, using compressed air at 80 lb. per sq. in. No elaborate installation is required, and the machines are portable. Heat is provided by two thermostatically controlled 3 kW immersion heaters fitted in the base of the tank, which is lagged to reduce heat losses.

The Agidip action consists in a regular and rapid up-and-down movement of the work container through two layers of di-phase solutions, causing the items in an easily removable work container to receive a thorough and penetrating dip in each phase in turn on each upward and downward movement. This action results in a thorough cleansing of both oil and water-soluble soils from the metal surfaces of the work.

The machines are of two sizes, with capacities of 20 lb. and 65 lb. per load. The cleaning cycle takes approximately two minutes, so that the potential hourly output is 5 cwt. or 16 cwt., respectively. The larger machine can conveniently handle such items as cylinder blocks and therefore should be of particular interest to the automobile and garage industries.

After cleaning in the Agidip the work may be dried at once by an air blow-off, or passed in a drying cycle through an Agidrier machine in which a current of hot air is fanned through the work as it moves up and down in an action similar to that of the Agidip.

Di-phase processes, originally introduced in the United States, employ two different and immiscible liquid cleaners which make contact with the work virtually simultaneously. These cleaners are becoming widely used in the automobile, engineering and appliance industries, and have the advantages of being non-toxic, rust-inhibiting, and together are capable of removing every type of soil from the metal surfaces to be cleaned. They also offer notable operating economies over trichlorethylene, and being used in concentrations of only 3 to 5 per cent. require no elaborate recovery process. They are equally suitable for ferrous and non-ferrous metals, including zinc, aluminium and magnesium.

A great improvement in the method of application of the di-phase cleaners has recently become possible by the development of the range of Agidip machines which are specially applicable to the batch cleaning treatment of small intricate components.

* * *

NEW RANGE OF LORRIES

Commer Cars, Limited, Luton, Bedfordshire, have announced a new range of "Superpoise" lorries ranging from 2 to 5 tons capacity and available in several forms. Particular attention has been paid to the driver's comfort and to ease of control. The cabs are integrally-welded structures built on an underframe which in turn is flexibly mounted on the main chassis. Extensive glazing with narrow columns allows good visibility.

The lorries are made with either six-cylinder petrol engines developing 91 h.p. or with Perkins P6 Diesel engines. An optional overdrive can be fitted to the standard four-speed synchromesh gearbox; it has a ratio of 0·822 to 1. This gives roughly a 10 per cent. increase in mileage per gallon. Alternatively, the Eaton two-speed rear axle can be fitted on the five-ton model. The lorries have all been tested on the Army vehicle proving grounds, and have undergone trials normally reserved for four-wheel drive vehicles.

By rotating the dial to the required angle and then moving the gauge round the work till the level bubble is again centred, lines can be layed-off at any relative angle.

CENTRE MARKER

A tool for marking centre lines on the inside or outside of round work, and which can also be used to lay-off lines at any angle round the work, has been introduced by Rediweld Limited, 15–17 Crampton-way, Crawley, Sussex. Known as the Boyce centre gauge it is shown in the illustration above.

The body of the tool is Y-shaped so that the legs form tangents to the work, and it is pierced to accommodate a hardened steel centre punch. On one face of the body is mounted a dial, calibrated in degrees, which carries an accurate spirit level. The dial is clamped by a wing nut, and can be rotated with the level to any desired angle as indicated by the mark on the tool body. When it is desired to mark a line at an angle from the vertical centre line, the dial is set to the mark and the tool moved round the work until the level bubble is again centred. Scale markings on the dial are at 2½ deg. intervals with every 10 degrees numbered. The punch is of ⅜ in. diameter. Examples of the use of this tool are the laying-off of keyways and the marking of pipe junctions. It can be used for inside as well as outside work.

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SPOT-WELDING MACHINE WITH FOURTEEN HEADS

The accompanying illustration shows a fourteen-head spot welding machine, which has been designed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for automatically welding spacing strips across the faces of grids made up of steel bars on edge.

After a grid and its spacing strips have been loaded into a jig the depression of a push button initiates the welding cycle and the jig table is indexed through the machine. When welding has been completed the table returns to its original position for unloading.

The kinked spacing strips are formed from $\frac{1}{16}$ in. by ½ in. mild steel strips, which are welded to the edge of ¼ in. black steel bars with depths up to 2 in. The strips are forged into the bars to about half their thickness. The machine can make 14 rows of welds per minute, so that a grid of 30 longitudinal bars can be finished in 126 seconds, giving an output of about 17 grids per hour allowing for loading time.

As regards construction, the machine consists of a welded steel arch frame with a clear span of 8 ft. on which the 14 electrode assemblies are mounted at 5 in. centres. Each of these assemblies is operated by a double-acting 1,000 lb. air cylinder with a bore of 3½ in. The electrodes are water-cooled and each pair is supplied with current from a 108 kVA air-cooled single-phase transformer.

The jig table, which runs under the arch on rails, is driven by a ½ h.p. three-phase squirrel-cage motor through worm-gearing and a Geneva mechanism. The control gear, which is mounted separately, includes seven ignitron contactors and two thyratron timers as well as the necessary relays and switches.

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OVENS FOR ARC-WELDING ELECTRODES

Benefits of Drying and Pre-Heating

A great deal of research has been carried out in recent years by the arc-welding industry with a view to discovering the causes of defects which may occur in high-strength welds, such as porosity, roughness and under-bead cracking. The results obtained have shown that a principal cause of these defects is moist electrodes and that, for certain classes of electrodes used in the shipbuilding industry, better welds are obtained if the welding rods are pre-heated within a temperature range of from 100 to 300 deg. C.

To meet these conditions, two electrically-heated ovens, specially designed for the drying out and pre-heating of arc-welding electrodes, have been placed on the market by Siemens-Schuckert (Great Britain) Limited, Faraday Works, Great West Road, Brentford, Middlesex. One is of the vertical type and is portable and the other is of the horizontal type. The former, which is shown in the accompanying illustration, is intended for use in places where floor space is restricted. An example of this is in the ship-building industry where welders carry out much of their work on scaffolding. The oven has a capacity for approximately 80 lb. of electrodes and its internal dimensions are: diameter 9 in., and height 18 in. The temperature range is from 75 deg. C. to 300 deg. C., and this is maintained by means of heating elements in the base of the oven, the temperature being adjusted by means of a thermostat. The rating of the oven is 1 kW so that it can be connected to a normal power plug.

The oven is fabricated from mild-steel plate, suitably reinforced, and the heating chamber is adequately insulated. As is seen in the illustration, the lid is operated by means of a pedal, thus allowing the welder the use of both his hands.

The horizontal oven is intended for workshop use where it may be placed on a bracket or bench. It has an internal diameter of 18 in. and a depth of 20 in., and is provided with three shelves, the heating elements being fitted under the lowest shelf. The oven is capable of holding a maximum of 3 cwt. of electrodes at temperatures between 75 and 300 deg. C., and is also thermostatically controlled. It has a rating of 1½ kW.

Portable electric oven with pedal-operated door for drying and pre-heating arc welding electrodes.

Like the vertical oven, the horizontal oven is fabricated of suitably reinforced mild-steel plate and its thermal efficiency is maintained by insulating material. Access to the oven is through a circular hinged door.

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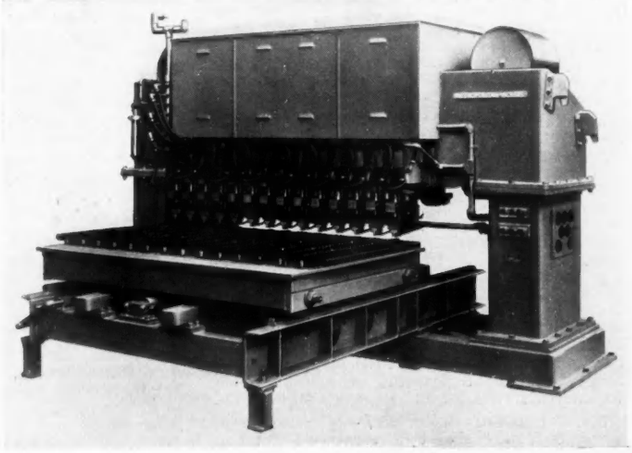
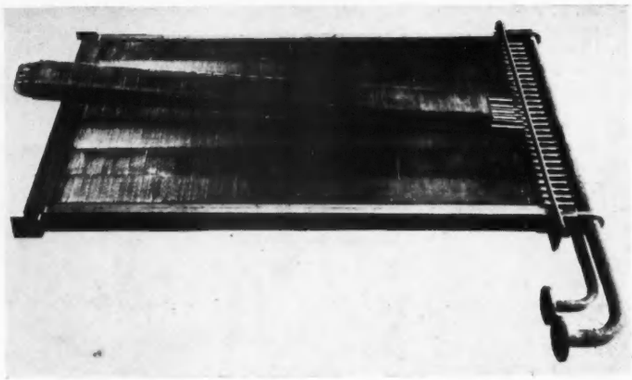
RECORD PIG-IRON OUTPUT

During the week ending October 2, the large Queen Victoria blast furnace at the Scunthorpe works of the Appleby-Frodingham Steel Company, a branch of the United Steel Companies, Limited, Sheffield, produced what is considered to be a world record output for lean iron ores of 11,160 tons of pig iron. Working entirely on low-grade British ores, averaging 20 per cent. iron content, it is believed to be the first occasion on which a British blast furnace has exceeded a five-figure tonnage in one week. The previous record, set up by the same furnace earlier this year, was 9,130 tons. The Appleby-Frodingham blast-furnace plant, comprising the four furnaces, Queen Mary, Queen Bess, Queen Anne, and Queen Victoria, together produced 27,280 tons of pig iron in the week ending October 2. This is claimed to be a record for the British industry.

Even higher outputs are envisaged when a new turbo-blower, costing over £750,000, comes into service early in 1957.



Fourteen-head spot welding machine and jig table. The jig table is indexed through the machine, and at the end of the welding cycle is returned to its original position for unloading.



The Serck steam air-heater is made up of units like this built into a lightweight frame.

STEAM AIR-HEATERS

Units for Use on Board Ship

The first of the steam air-heaters now being made by Serck Radiators, Limited, Warwick-road, Birmingham, 11, have been installed on the S.T.S. Vexilla for use as preheaters. Each has a normal capacity for raising 79,000 lb. of air per hour from 80 deg. F. to 260 deg. F., or a maximum of 90,000 lb. per hour with an outlet temperature 6 deg. less. In the first case steam at 50 lb. per sq. in. abs. and 370 deg. F. is used and in the second, 57·5 lb. per sq. in. and 480 deg. F. A single element of the heater, with one section removed, is shown in the illustration.

The heaters are designed to use bled steam from a manifold which is connected to the larger of the two pipes. Four U-tubes run the length of each section and through these the steam passes and is returned to the drains collecting pot by a separate pipe from each element. Steam traps are essential, as operation of the heaters must be free from water hammer—a necessary condition for all steam-heated exchangers. The U-tubes are $\frac{5}{8}$ in. outside diameter and made from 18 s.w.g. 90/10 cupro-nickel alloy. The fins, which are threaded on them and bonded in place, are made of pure copper 0·015 in. thick spaced seven to the inch. The bond is made either by brazing in a reducing atmosphere or by high temperature soldering, as specified. As only one end of the assembly is fixed, the U-tubes are free to expand as they become heated. The materials used give a very good heat transfer together with low weight.

A continuous air vent, with a strainer, is arranged so that the drain header of each element of the header can operate free of air pockets. Each element can be withdrawn on runners for inspection or repair, and the heater can be arranged for either horizontal or vertical air flow. At the normal rating of 79,000 lb. of air per hour, the pressure loss through the heater is 2·3 in. of water. At the maximum flow this is increased to 3 in. The heater is resistant to atmospheric corrosion and also to the effects of superheated steam up to a temperature of 650 deg. F.

LAUNCHES AND TRIAL TRIPS

M.S. "SUGAR EXPORTER."—Single-screw cargo vessel, built by Hall, Russell & Co., Ltd., Aberdeen, for Silvertown Services, Ltd., London, E.C.3. Main dimensions; 330 ft. between perpendiculars by 50 ft. by 26 ft. 6 in.; deadweight capacity, about 5,250 tons on a draught of 22 ft. 2 in. Two eight-cylinder direct-reversing Diesel engines, together developing 3,040 b.h.p. at 300 r.p.m., each engine being connected through hydraulic couplings and reduction gearing to a single shaft running at 150 r.p.m. Propelling machinery supplied by British Polar Engines Ltd., Glasgow and installed by the shipbuilders. Launch, September 19.

M.S. "BOSTON FURY."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the Boston Deep Sea Fishing and Ice Co., Ltd., Grimsby. Second of three trawlers of a new class for these owners. Main dimensions: 180 ft. overall by 30 ft. by 15 ft. 3 in.; fishroom capacity, 14,700 cub. ft. Eight-cylinder marine Diesel engine, developing 1,050 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by Amos and Smith, Ltd., Hull. Launch, September 19.

S.S. "PIZARRO."—Single-screw cargo vessel, with accommodation for twelve passengers, built by the Greenock Dockyard Co., Ltd., Greenock, for the Pacific Steam Navigation Co., Liverpool. Fourth vessel of this type constructed for these owners. Main dimensions: 476 ft. between perpendiculars by 66 ft. by 40 ft. 8 in. to upper deck; gross tonnage, about 8,560; deadweight capacity, 11,100 tons on a mean draught of 28 ft. Reaction steam turbines with double-reduction gearing, developing 9,400 s.h.p. at 108 r.p.m. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Steam supplied by two oil-fired marine water-tube boilers, constructed by Babcock and Wilcox, Ltd., London, E.C.4. Propelling machinery installed by John G. Kincaid & Co., Ltd., Greenock. Speed, 16½ knots in service. Trial trip, September 19 and 20.

S.S. "STANVAC AUSTRALIA."—Single-screw oil tanker, built and engined by John Brown & Co., Ltd., Clydebank, for the Standard-Vacuum Transportation Co., Ltd., London, W.C.2. Main dimensions: 628 ft. by 85 ft. 6 in. by 42 ft. 5 in.; deadweight capacity, 26,650 tons on a draught of about 32 ft. Propulsion by geared steam turbines developing 12,500 s.h.p. Speed, 17 knots. Trial trip, September 20.

S.S. "ALVEGA."—Single-screw oil tanker, built and engined by John Brown & Co., Ltd., Clydebank, for the Alvion Steamship Corporation, Panama (Agents: Navigation and Coal Trade Co., Ltd., London, E.C.3). Main dimensions: 640 ft. between perpendiculars by 86 ft. 6 in. by 46 ft. 3 in.; deadweight capacity, 32,000 tons on a draught of about 34 ft. 4 in.; gross tonnage, 21,300. Propelled by double-reduction geared steam turbines. Speed, 14¾ knots. Launch, September 21.

M.S. "ABISKO."—Single-screw cargo vessel, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Trafikaktiebolaget Grängesberg-Oxelösund, Stockholm, Sweden. Main dimensions: 490 ft. overall by 64 ft. by 42 ft. 6 in.; deadweight capacity, 13,000 tons on a draught of about 27 ft. 6 in. Götaverken seven-cylinder single-acting two-stroke Diesel engine, developing 5,000 b.h.p. at 112 r.p.m. Speed, 14½ knots fully loaded. Launch, September 21.

M.S. "SANDRINGHAM QUEEN."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for Queenship Navigation Ltd., London, E.C.3. Main dimensions: 220 ft. between perpendiculars by 35 ft. 6 in. by 15 ft. 6 in.; deadweight capacity, about 1,710 tons. Seven-cylinder Diesel engine, developing 1,120 b.h.p. at 250 r.p.m., constructed by British Polar Engines Ltd., Glasgow. Speed, 12 knots. Trial trip, September 27.

M.S. "RED CREST."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for the Iago Steam Trawler Co., Ltd., Fleetwood, Lancashire. Second of two sister ships. Main dimensions: 135 ft. between perpendiculars by 26 ft. 6 in. by 13 ft. 3 in.; fishroom capacity, about 9,300 cub. ft.; gross tonnage, 402. Five-cylinder Diesel engine developing 800 b.h.p. at 250 r.p.m., constructed by British Polar Engines Ltd., Glasgow. Trial trip, September 28.

M.S. "CITY OF WINNIPEG."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Far East trade of Ellerman Lines Ltd., London, E.C.3. Main dimensions: 505 ft. overall by 65 ft. 6 in. by 42 ft. to shelter deck; deadweight capacity, about 10,200 tons. Six-cylinder opposed-piston oil engine, developing 8,000 b.h.p. at 105 r.p.m., constructed by William Doxford and Sons, Ltd., Sunderland. Service speed, 15 knots. Launch, September 29.

H.M.S. "TENBY."—Whitby class anti-submarine frigate, built by Cammell Laird & Co., Ltd., Birkenhead, for the Admiralty, London, S.W.1. Length 370 ft. overall; and beam 41 ft. Designed primarily for the location of submarines of the most modern types, and accordingly fitted with underwater detection equipment and anti-submarine weapons embodying the latest post-war developments. Armament comprises two 4·5-in. guns and two smaller guns. Propelled by geared steam turbines of high power. Launch, October 4.

H.M.S. "BLACKWOOD."—Anti-submarine frigate, built by John I. Thornycroft & Co., Ltd., Southampton, for the Admiralty, London, S.W.1. Length 310 ft. overall, and beam 33 ft. Armament comprises three Bofors guns and two three-barrelled anti-submarine mortars. Propulsion provided by geared steam turbines constructed by the shipbuilders. Launch, October 4.

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LOG-SAW AND WINCH

Interchangeable Petrol Driven Machine

J. Clubley Armstrong Danarm, Limited, Abford House, Wilton-road, London, S.W.1, have recently added to their range the "Fury" chain saw and the "Falcon" winch. These two items are driven by the same petrol engine and can be interchanged. The Fury saw is a larger version of the Whipper and can handle timber of greater diameter—up to 30 in., or more if a special guide blade is fitted.

The engine for the Fury saw has been designed for this application. It has a bore and stroke of 50 mm., giving a rating of 4 h.p. The cylinder block is aluminium and the cylinder walls are chromium plated by the "Honeychrome" process. A rotary valve has been used in this engine as this allows timed induction to suit the requirements of the particular operation. There is a centrifugal clutch which has the advantages of leaving the operator's hands free for control and guidance, and of providing protection for the gearbox in the event of the chain jamming. It is also a safety measure in that the chain will stop as soon as the spring-loaded throttle lever is released. Bevel gears, of a ratio chosen to allow large cutter bars to be used without reducing engine speed, have been employed to permit the guide plate of the saw to be rotated to any angle in relation to the engine. This is necessary in order that the saw may handle fallen as well as standing timber. Positive lubrication is supplied by a mechanically-driven pump with a visual sight glass and oil level indicator. The rate can be adjusted to suit requirements.

The standard cutting chain used is the Danarm-Oregon Chipper type, but a Scratcher type can be fitted if desired. The cutting speed in elm is 7 sq. in. per sec. Oil is fed directly on to the chain by oilways, and the guide blade is stellite-tipped to reduce wear.

The Falcon winch can be driven from both the Whipper and Fury engines by direct replacement of the saw blade. The exchange can be carried out in a few minutes. A pull of 15 cwt. can be obtained with the Fury engine; with the smaller Whipper engine the pull is 9 cwt. Drum capacity is 125 ft. of ¼-in. cable. It is suitable for all general purpose hauling or lifting and such other purposes as stretching fence wires. A ground anchor is available for use where there is no natural fixing. Being completely portable (it weights approximately 29 lb. without the cable) it can be very useful in agricultural and constructional work.

NOTICES OF MEETINGS

Aslib

LONDON
"Should a New Public Technical Library be Based on the Technical Colleges?" by Dr. D. J. Urquhart. Chaucer House, Malet-place, W.C.1. Fri., Oct. 21, 6 p.m.

Association of Supervising Electrical Engineers

LONDON
Presidential Address. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Oct. 18, 6.30 p.m.
NOTTINGHAM
"Alternating-Current Polyphase Shunt Characteristic Commutator Motors," by A. C. Lane. Nottingham Branch. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Wed., Oct. 19, 7.30 p.m.
OXFORD
"Water Heating," by A. Hughes. Oxford and Reading Branch. Y.M.C.A., 10 George-street, Oxford. Sat., Oct. 22, 6.30 p.m.
PORTSMOUTH
"Electrical Engineering in Persia," by S. H. Allen. Portsmouth Branch. 598 Commercial-road, Mile End, Portsmouth. Tues., Oct. 18, 7.30 p.m.

British Coal Utilisation Research Association

LONDON
"The Carbon of Coal," by Professor Sir Cyril Hinshelwood. Fourth Coal Science Lecture. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Oct. 19, 5.30 p.m.

Building Centre

LONDON
Film on "Fural Aluminium Roofing and Wall Cladding." Wed., Oct. 19, 12.45 p.m.

Chemical Engineering Group

LONDON
"Decolorisation of Sugar Liquor by Solid Absorbents," by H. C. S. de Whalley. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Tues., Oct. 18, 5.30 p.m.

Chemical Society

LONDON
Centenary Lecture on "The Photosynthetic Carbon Cycle," by Professor M. Calvin. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Oct. 20, 7.30 p.m.
BELFAST
"Silicones: Their Chemistry and Technology," by Dr. G. G. Freeman. Northern Ireland Branch. Queen's University, Belfast. Thurs., Oct. 20, 7.15 p.m.
BRISTOL
"Organic Inclusion Compounds and Their Uses," by Professor Wilson Baker. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Oct. 20, 7 p.m.
GLOUCESTER
"Some Newer Plastic Materials," by Dr. E. M. Evans. Bristol Branch. Technical College, Brunswick-road, Gloucester. Wed., Oct. 19, 6.30 p.m.
LEICESTER
"Hydrogen Transfer Reactions," by Professor E. A. Braude. Nottingham Branch. Mon., Oct. 17, 4.30 p.m.

Diesel Engine Users Association

LONDON
"Diesel Engines: Design for Service," by C. H. Bradbury. Annual General Meeting. Caxton Hall, Victoria-street, S.W.1. Thurs., Oct. 20, 2 p.m.

Illuminating Engineering Society

GLOUCESTER
"Home Lighting," by Mrs. Jean L. Stewart. Gloucester and Cheltenham Centre. Fleece Hotel, Westgate-street, Gloucester. Wed., Oct. 19, 6.30 p.m.
LIVERPOOL
Chairman's Address by G. L. Butler. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Tues., Oct. 18, 6 p.m.

Incorporated Plant Engineers

LONDON
"The 1400 Excavator," by C. McL. Cameron. College of Preceptors, Bloomsbury-square, W.C.1. Thurs., Oct. 20, 7 p.m.
BLACKBURN
"Repair of Fractured Castings," by N. Tinwell. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Oct. 20, 7.30 p.m.
CARDIFF
"Safety in Industry," by F. W. Thompson. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 25, 7.15 p.m.

Institute of British Foundrymen

IPSWICH
Presidential Address on "Taking Stock: Science, the Foreman and Discipline," by W. E. Cates. East Anglian Section. Public Library, Old Foundry-road entrance, Ipswich. Tues., Oct. 18, 7.30 p.m.

Institute of Fuel

MANCHESTER
"Coal Preparation and Evaluation," by J. K. Matthews. North-Western Section. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 20, 7 p.m.

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"Freeboard and Stability," by J. H. Cox. Southern Joint Branch. Technical College, St. Mary-street, Southampton. Tues., Oct. 18, 7.30 p.m.

Institute of Marine Engineers

LONDON
Films, including "The Sea Shall Test Her." Student Meeting. Mon., Oct. 17, 6.30 p.m.
LIVERPOOL
"Launching of Ships," by R. S. Hogg. Merseyside and North Western Section. Riversdale Technical College, Liverpool. Wed., Oct. 19, 5.30 p.m.
NEWCASTLE-UPON-TYNE
"Practical Approach to Some Vibration and Machinery Problems in Ships," by T. W. Bunyan. North East Coast Section. Stephenson Buildings, King's College, Claremont-road, Newcastle-upon-Tyne. Thurs., Oct. 20, 6.15 p.m.

Institute of Road Transport Engineers

LONDON
"Mechanical-Handling Equipment in Relation to Commercial Road Transport," by C. S. Shaw. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Oct. 20, 6.30 p.m.
EDINBURGH
"Clutch and Brake Linings," by L. P. Godfrey. Scottish Centre. North British Hotel, Edinburgh. Mon., Oct. 17, 7.30 p.m.
LEEDS
"The Use of Fibre Glass and Polyester Resins on Public Service and Commercial Vehicles," by B. S. Parkyn. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds 1. Thurs., Oct. 20, 7.30 p.m.

Institution of Chemical Engineers

NOTTINGHAM
"The Mechanism of Operation of Bubble Cap Plates," by Professor F. H. Garner. Midlands Branch. The University, Nottingham. Sat., Oct. 15, 3 p.m.

Institution of Civil Engineers

LONDON
"Uses of Aerated Cement Grout and Mortar in the Stabilisation of Slips, Large-Scale Tunnel Repairs and Other Works," by M. C. Purbrick and D. J. Ayres. Tues., Oct. 18, 5.30 p.m.
HULL
Chairman's Address by S. Maynard Lovell. Yorkshire Association. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., Oct. 18, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Railway Signalling," opened by J. H. Fraser. Mon., Oct. 17, 5.30 p.m.
Discussion on "Analogues and Equivalent Circuits," opened by W. A. Turner. Education Discussion Circle. Tues., Oct. 18, 6 p.m.
Chairman's Address by H. Stanesby. Radio and Telecommunication Section. Wed., Oct. 19, 5.30 p.m.
ARBORFIELD
Chairman's Address on "Alternating-Current Switchgear," by M. H. F. Collins. London Graduates' and Students' Section. R.E.M.E. Training Centre, Bailleul Barracks, Arborfield, Berks. Tues., Oct. 18, 7 p.m.
EDINBURGH
"Thermionic Valves of Improved Quality for Government and Industrial Purposes," by E. G. Rowe, P. Welch and W.W. Wright. Scottish Centre. Heriot-Watt College, Chambers-street, Edinburgh. Tues., Oct. 18, 7 p.m.
HULL
"Radio Aids to Marine Navigation," by Captain R. G. Swallow, R.N. ret'd. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., Oct. 20, 7.15 p.m.
LIVERPOOL
"High-Speed Electronic-Analogue Computing Techniques," by Dr. D. M. MacKay. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Oct. 17, 6.30 p.m.
SOUTHAMPTON
"A Transatlantic Telephone Cable," by Dr. M. J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey. Southern Centre. The University, Southampton. Wed., Oct. 19, 7.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Resistance Experiments on an 18 ft. Plank," by Dr. J. F. Allan and R. S. Cutland. Tues., Oct. 18, 7.30 p.m.

Institution of Heating and Ventilating Engineers

SHEFFIELD
"Ventilation of Factories and Foundries," by John MacColl. Yorkshire Branch. Royal Victoria Hotel, Sheffield. Wed., Oct. 19, 7.30 p.m.

Institution of Mechanical Engineers

LONDON
Presidential Address by P. L. Jones. Fri., Oct. 21, 5.30 p.m.
MANCHESTER
"Industrial Training with Particular Reference to Atomic-Energy Factories," by K. J. Frost. North Western Graduates' Section. Engineers' Club, Albert-square, Manchester. Tues., Oct. 18, 6.30 p.m.
"The Development and Scope of Work Study," by R. M. Currie. North Western Industrial Administration and Engineering Production Group. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 20, 6.45 p.m.
SOUTHAMPTON
Chairman's Address on "Internal-Combustion Engines Applied to Marine Craft," by K. Roberts. Southern Graduates' Section. Polygon Hotel, Southampton. Wed., Oct. 19, 7.30 p.m.

Institution of Mining and Metallurgy

LONDON
"Research as a Business Enterprise," by F. H. Chapman; and "Pressure Manifestations at Great Mining Depths on the Witwatersrand," by J. F. G. R. Heywood. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Thurs., Oct. 20, 5 p.m.

Institution of Production Engineers

BIRMINGHAM
"Application of Electronics to Industry," by J. B. C. Robinson. Birmingham Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Oct. 19, 7 p.m.
COVENTRY
"Bridging the Handling Gap," by J. Bright. Coventry Section. Craven Arms, High-street, Coventry. Tues., Oct. 18, 7 p.m.
GLASGOW
"Unusual Products that can be Made from Tube," by A. N. Attwood. Glasgow Section. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 20, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Work Study as Applied to Engineering Operations," by Dr. H. E. North. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 17, 7 p.m.
SOUTHAMPTON
"Gas Turbines: Basic Principles and Production Problems," by C. E. Wurr. Southern Section. Polygon Hotel, Southampton. Thurs., Oct. 20, 7.15 p.m.
WOLVERHAMPTON
"Plant Maintenance and Productivity," by R. A. Rogers. Wolverhampton Section. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., Oct. 19, 7.15 p.m.

Institution of Structural Engineers

LEEDS
Chairman's Address by Professor R. H. Evans. Yorkshire Branch. Great Northern Hotel, Leeds. Wed., Oct. 19, 6.30 p.m.
MANCHESTER
Chairman's Address by J. H. Morris. Lancashire and Cheshire Branch. College of Technology, Manchester. Thurs., Oct. 20, 7.15 p.m.

Institution of Works Managers

LIVERPOOL
"The Team Spirit and How to Obtain it," by Dr. Dennis Chapman. Merseyside Branch. Adelphi Hotel, Liverpool. Tues., Oct. 18, 6.30 p.m.

Iron and Steel Institute

MANCHESTER
"Fuel Efficiency in the Iron and Steel Industry," by Dr. W. S. Walker. Iron and Steel Engineers Group. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 20, 10,30 a.m.
SHEFFIELD
"Trends in Metallurgical Research in the United States," by Dr. E. C. Bain. Eighth Hatfield Memorial Lecture. Firth Hall, The University, Sheffield. Mon., Oct. 17, 6.30 p.m.

Junior Institution of Engineers

LONDON
"The Atom," by S. A. McAuliffe. Fri., Oct. 21, 7 p.m.

Royal Meteorological Society

LONDON
Various short papers. Wed., Oct. 19, 5 p.m.

Royal Society for the Promotion of Health

LONDON
Discussion on "The Clean Air Bill," opened by Sir Hugh Beaver and Dr. J. A. Scott. Caxton Hall, Victoria-street, S.W.1. Mon., Oct. 17, 2.30 p.m.

Royal Statistical Society

BRISTOL
"Personnel Statistics," by H. E. Bishop. Bristol Study Group. The University, Bristol 8. Thurs., Oct. 20, 5.45 p.m.

Scientific Film Association

LONDON
Presidential Address by Sir Arthur Elton, Bt. Mezzanine Cinema, Shell-Mex House, Strand, W.C.2. Tues., Oct. 18, 6.30 p.m.

Société des Ingénieurs Civils de France (British Section)

LONDON
"Reconstruction of the Swing Span of the Caronte Viaduct," by Lucien Carpentier. Institution of Civil Engineers, Great George-street, S.W.1. Mon., Oct. 17, 5.30 p.m.

Society of Instrument Technology

MIDDLESBROUGH
"Use of Isotopes in Industry," by E. W. Jones and E. B. Bell. Tees-Side Section. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Wed., Oct. 19, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Instruments Applied to Nuclear Power," by R. K. Sandiford. Newcastle Section. Stephenson Building, King's College, Newcastle-upon-Tyne. Wed., Oct., 19, 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
Presidential Address by S. Thomson. Fri., Oct. 21, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Aslib, 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Coal Utilisation Research Association, Randalls-road, Leatherhead, Surrey. (Leatherhead 4411.)
Building Centre, 26 Store-street, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engine Users Association, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. (SLOane 0061.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society for the Promotion of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.1. (TEMple Bar 6189.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street, London, S.W.1. (VICtoria 6838.)
Society of Instrument Technology, 184 Sherwood Park-road, Mitcham, Surrey. (POLlards 3620.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

THE HUMAN ELEMENT

Ministry of Labour returns suggest movement of labour towards capital goods industries, while unemployment remains below one per cent. Printing industry seeks to apply modern management techniques. Aircraft executives step from public to private enterprise. Attempts to reduce production costs in motor-car firms cause labour troubles. The appeal of automatic control in process industries. Management and trade union representatives exchange views after dinner.

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Unemployment Keeps Its Record

When Lord Beveridge worked out his national unemployment insurance scheme he put full employment at 3 per cent. unemployed—a figure which to-day would be considered bad enough to be called an economic crisis. As at the middle of September, the number of unemployed was estimated by the Ministry of Labour to be 0·9 per cent., which is the same percentage of the employed population as in August and slightly lower than a year ago. In September, 1954, the percentage was 1·1. The total employed population during August was 24,010,000 or an increase of 90,000 on the month. The important fact, however, is that right through the height of the summer the unemployment figure has kept below 1 per cent.

Taking the August returns as the latest available in any detail, the net increase of 90,000 has an interesting feature about it. Exactly half of this accrued to manufacturing industry and the biggest gain was 13,000 in engineering and metal goods. Only textiles actually shed labour. Engineering, metals and vehicles taken altogether took on an additional 29,000 workers.

It is a little early to see what this means. Obviously, if this movement of labour towards engineering and metals continues it will be a favourable sign for the national economy, for it will mean a shift of labour, however small, in the direction of the capital goods industries and the kind of movement that the Government is anxious to bring about.

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Wages and Work Study

A wide difference in attitude is apparent in the negotiations now going forward in the printing industry about wage increases in general printing houses and provincial newspapers. It will be recalled that some weeks ago there was broad agreement between the unions and the national newspapers about wage increases, a feature of that settlement being the decision to abandon the sliding scale arrangements. In the negotiations covering general printing works and provincial papers, the employers say that they too are prepared to abandon the sliding scale and would also consolidate the adjustable bonus at its present level. Learners' and apprentices' scales would also be adjusted. They are not prepared to concede the six unions' demands for higher basic wages. They will agree to some increase in basic rates if labour co-operates in reducing the shortage of recruits and helps to encourage the efficient use of workers.

This raises a basic issue for the printing industry. The tradition of craftsmanship and the closed shop is strong and limitation of recruitment has been enforced by the craft unions for many years. The employers are in fact pressing for a measure of elementary work study, and if they could get co-operation on this, including the down-grading of some jobs, they would probably be in a position to reduce their demands for new recruits. So far, anything approaching work study has not commended itself to workers who are employed in an industry which is not very much exposed to foreign competition. Also, until the national papers are free from newsprint rationing and they have settled down to a freer supply position, their requirements for additional skilled workers are not easy to foresee. In the long run, as the operatives are doubtless well aware, the printing industry can ill afford to obstruct the employment of modern management techniques.

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Public Figures go to Industry

Two men who since the war have built themselves up into public figures through their leadership of fast-growing public enterprises have stepped into comparative obscurity—and, no doubt, into substantially higher incomes. First, Mr. Peter Masefield, chief executive of British European Airways, will be leaving the corporation next month to join the Bristol Aeroplane Company and will become managing director of a new subsidiary, Bristol Aircraft Limited. Number two is Mr. Whitney Straight, deputy chairman and managing director of British Overseas Airways Corporation, who on November 1 will join the board of Rolls-Royce to take over the duties of executive vice-chairman of the company at the New Year.

While it could be argued that outstanding ability will " out " whatever the circumstances, to be chief executive of a public corporation so much in the public eye and in the process of rapid growth must considerably assist personal progress. Such positions tend to underline success as well as failure. Mr. Masefield and Mr. Straight will now be able to apply to their new jobs the vast and varied experience they have gained as administrators of a very large organisation and as operators of aircraft. The industry, so costly to the tax-payer, often in the past fanciful about its development and research, and always having to contend with the views of enthusiastic designers—from its own ranks, those of the Government and those of operators —is in need of practical men of authority. At the same time it is to be hoped that all leading public men and civil servants do not go in the same direction when in their prime; a two-way traffic would benefit everyone.

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Redundancy in West Midlands

Last week 2,000 men struck to press the reinstatement of 268 body-builders who had been declared redundant by the Daimler Company, Limited, in Coventry, and several thousand employees of the Rover Company in Solihull were put on a four-day week. The causes, however, were very different. Rover are experiencing a sharp reduction in the overseas demand for the Land-Rover, due they say to import restrictions in Australia and elsewhere. Daimler are endeavouring to concentrate car body building, and so reduce production costs. They found, to their cost, that redundancy is a powerfully emotional word —even in time of full employment—and also that to revise piece rates downwards is a ticklish business.

The dispute first arose over an attempt by the management to introduce a fixed piece-work rate for the job of applying finishing touches to cars, which had previously been paid according to what amounted to a fixed time rate (piece rate plus " make-up money "). The 30 men concerned resigned and were replaced, but several hundred of unfinished cars accumulated and the management gave 268 body-builders one week's pay in lieu of notice. The shop stewards protested that this violated an agreement by which the company would inform them 48 hours before declaring any employees redundant and would give them an opportunity to comment on the names selected. The district committee of the National Union of Vehicle Builders, to which most of the men belonged, asked for their immediate reinstatement pending negotiations; they were refused and 2,000 men came out on strike. Six days later followed a settlement which included a guarantee that the company would give preference to the laid-off men when re-engaging labour. Thus ended a most unprofitable dispute, and one which the facts published so far suggest could have been avoided given better communications and relationships between management and employees.

* * *

Automation for All

Automation will come about in a variety of ways, not necessarily as a direct means of economising in manpower, and it will come for the large and small industries alike. These are two of the general conclusions which can be derived from the remarks made at a one-day conference on automatic control in process industries organised last week by the Institution of Chemical Engineers and the Society of Instrument Technology.

More research into the application of automatic processing was needed, according to the President of the Institution, Mr. J. A. Oriel, in his opening remarks. Remarks by other speakers showed that the appeal of such controls to management will come from a variety of causes. Economies in materials and fuel may conceivably be the impelling factor in winning over companies to increasing their instrumentation and automatic controls rather than any wish to change the deployment of their manpower.

Discussions of this kind are valuable. They create the climate in which progress in the introduction of automatic devices can be obtained with the maximum exchange of knowledge on the subject. But the time is approaching when a basic issue will have to receive a good deal of public discussion if labour and management are to agree on the virtues of automation in a spirit of mutual accommodation. It may be easy to show that automation is necessary for this country to keep its costs down and so compete effectively abroad, but what will be management's policy on automation in times of falling output? Is an age of much bigger volume and value of capital equipment per worker going to make jobs more or less secure, and what are the factors affecting the issue?

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The Eleven Club

There took place at the Dorchester last week an after-dinner debate on " The Future Co-operation of Industry," initiated by Mr. Robert Asquith, chairman of the Asquith Machine Tool Corporation and chairman of the Eleven Club. The dinner was given to members of Council of the Trades Union Congress, and a number of leading industrialists were invited to meet them. Among the contributors to the debate were Mr. Tom Williamson, chairman of the Productivity Council of the Labour Party, Mr. Charles Geddes, who has just finished his year of office at the T.U.C., and Mr. Tom O'Brien, M.P.

The Eleven Club was founded " to meet, greet and exchange views of the persons engaged in industry, embracing industrial, political and social aspects of our way of life with a view to strengthening relationships and establishing ways and means of progressing the well-being of the country's structure." To make possible a frank exchange of view all that is said is strictly off-the-record.

The more candidly people are prepared to discuss their problems, the more likely they are to promote understanding of their own points of view and to understand those of others. There is little doubt that the gatherings of the Eleven Club and their guests make this possible, though it is difficult to conceive eleven men—most of them relatively young highly successful industrialists—achieving the lofty aims stated above by what amounts to judicious " lobbying " of people in industry. After-dinner atmospheres are probably more conducive to geniality than to a realistic appraisal of difficult social and political problems. But geniality sometimes leaves a residue of constructiveness for the morning after the night before.